

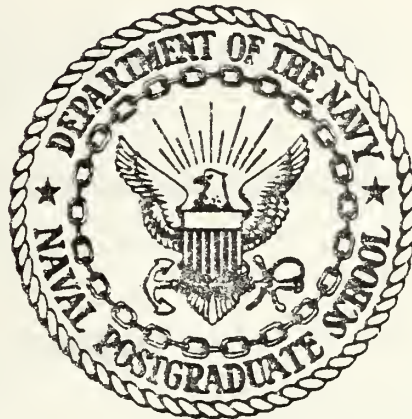
THE DEVELOPMENT AND IMPLEMENTATION OF  
ALGORITHMS FOR AN A-7E PERFORMANCE  
CALCULATOR

Gary Lang Koger



# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



# THESIS

The Development and Implementation  
of Algorithms for an A-7E  
Performance Calculator

by

Gary Lang Koger

September 1978

Thesis Advisor:

R. Panholzer

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Implementation was demonstrated on a desk computer, a hand held calculator and a microprocessor.



The Development and Implementation of Algorithms  
for an A-7E Performance Calculator

by

Gary Lang Koger  
Lieutenant, United States Navy  
B.S. United States Naval Academy, 1971

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## ABSTRACT

In this thesis, the algorithms for an A-7E aircraft performance calculator were developed and then implemented on three small data processors of different programming levels and storage capabilities.

The utility of data is a function of several variables including accuracy and availability. The problem of retrieving performance data from the Naval Air Training and Operating Procedures Standardization (NATOPS) Manuals is significantly lessened by the devices demonstrated in this investigation. Nine performance chart groups, yielding data usually considered necessary for flight, were reduced to a series of analytical expressions. These analytical expressions were demonstrated to reproduce NATOPS Manual data to a high degree of accuracy.

Implementation was demonstrated on a desk computer, a hand held calculator and a microprocessor.





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For the original development concepts and enthusiasm for this investigation completion, LCDR W.M. Siegel is hereby acknowledged.





## I. INTRODUCTION

The Naval Air Training and Operating Standardization (NATOPS) Manual is the official standard of the United States Navy for "...information on all aircraft systems, performance data, and operating procedures required for safe and effective operations." [1]

The purpose of this thesis was to develop algorithms of the more often used NATOPS performance charts for the A-7E aircraft, examine their accuracy and implement them on small data processors that might be adaptable to shipboard or aircraft onboard use. The interpretation of NATOPS performance charts is an error prone and time consuming procedure even for experienced users. The need for a system to eliminate this laborious process has been fully documented in a thesis completed in June 1978 by LCDR W.M. Siegel [2]. In his investigation, LCDR Siegel devised an efficient procedure to develop algorithms from the NATOPS performance charts and exercised this procedure on the problems of "Takeoff Ground Roll Distance" and "Takeoff Airspeed".

This investigation is an extension of the aforementioned work. The original scope of this investigation was to develop algorithms for eleven of the most often used performance problem chart groups and implement them on the Texas Instruments-59 (TI-59) hand held calculator (HHC). All of the NATOPS performance charts were not reduced because of research time limitations. Of the eleven performance chart groups studied,



two performance problems, "Time to Climb" and "Fuel Required to Climb" were rejected because of implementation difficulties on the TI-59 HHC (discussed fully in "Development Difficulties"). Therefore, nine performance chart groups were reduced to analytical expressions and implemented on the TI-59 HHC. To show further possibilities and feasibility of implementation of the algorithms, they were 1) fully implemented on the Hewlett Packard-9830 (HP-9830) desk computer, 2) demonstrated on a microprocessor (INTEL Corporation Microcomputer System-48), and 3) considered for implementation on the A-7E onboard digital computer and a microprocessor utilizing a recently developed number processing chip by the National Semiconductor Corporation (MM57109).



## II. DEVELOPMENT

### A. GUIDELINES

The scope of this investigation was established after a firm set of guidelines was defined.

Being the official United States Navy standard for the A-7E aircraft, the A-7E NATOPS Manual was the sole source of performance data used to develop the algorithms. As such, and being subject to changes during the aircraft's life cycle, the need for possible future updates to the algorithms was acknowledged. The effective date of the NATOPS Manual from which these algorithms were developed is March 1975. Since the performance data yielded by the algorithms was identical to NATOPS Manual performance curves, the same restrictions and limitations apply. For example, takeoff airspeed calculation restricts the NATOPS Manual user to trailing edge flap positions between 20 and 40 degrees down (Figure 1). For that reason, one could not expect to calculate the flaps up takeoff airspeed using the developed algorithms. An additional feature provided by the algorithms was higher order interpolation. While the inexperienced NATOPS user might attempt to interpolate linearly between non-linearly spaced curves, the algorithms do not.

An important guideline for the user's benefit was to ensure the execution of these algorithms after implementation was simple enough so very little training was required for the users. Intended users were Naval Flight Officers and Aviators.



# TAKEOFF SPEED (A-7E)

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

CONDITIONS:  
MILITARY RATED THRUST  
LANDING CONFIGURATION  
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL

## NOTE

Date basis is 25% MAC. Increase speed 1/2 knot per 1% forward CG shift. Decrease speed 1/2 knot per 1% aft CG shift.

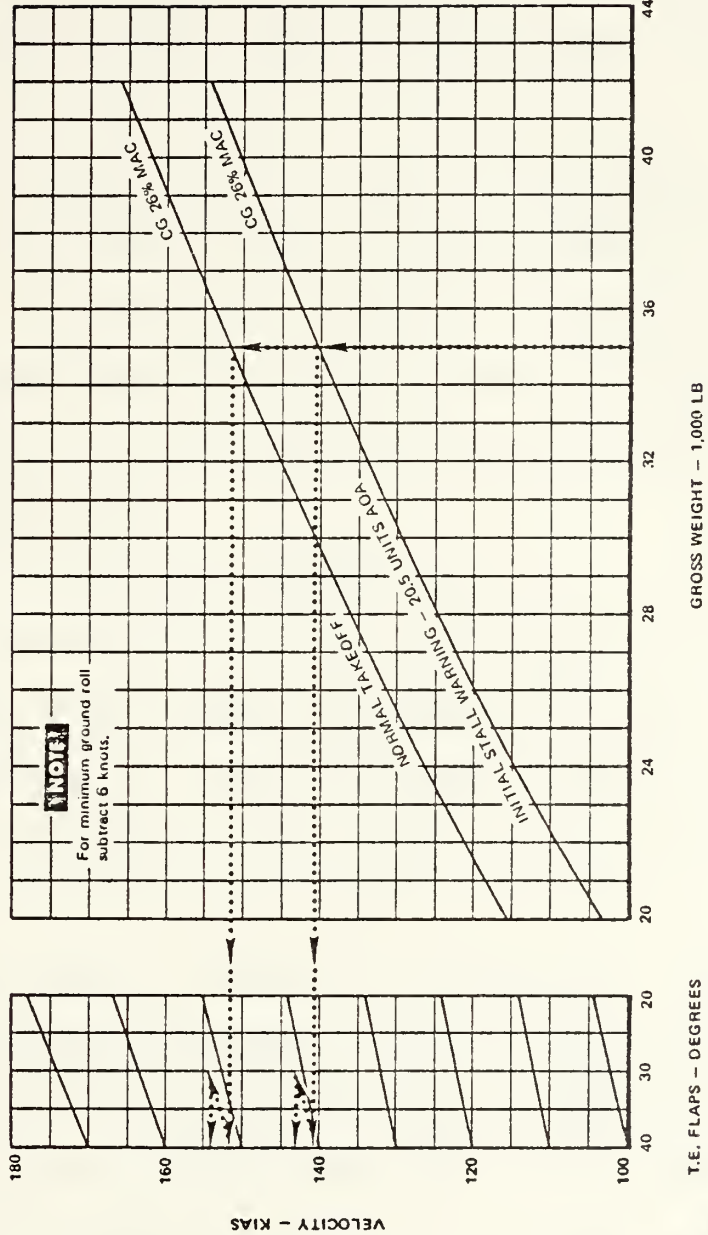


Figure 1

Takeoff Speed NATOPS Chart





Not included in the scope of this thesis is an introduction to the TI-59 HHC, HP-9830 desk computer and the INTEL Microcomputer System-48; however, to follow the computer programs written for these devices would required their basic understanding.

Another guideline established was that the performance calculators be light and small enough to be physically suited for its environment. For example, the TI-59 calculator and microprocessor could be used in a cockpit, briefing room or Air Operations Center. The HP-9830 desk computer would be restricted from cockpit use.

Reliability was a necessary guideline.

To make algorithm implementation on the TI-59 HHC feasible and since the program storing chip, the Continuous Read Only Memory (CROM), was limited to 5000 calculator program steps, the library of nine programs was required to fit into that space [3].

Finally, accuracy was a necessary consideration. The results obtained from the algorithms were required to be at least as accurate as following the performance charts manually. These accuracy requirements established were: One knot of air-speed, 100 feet of altitude or ground roll distance, 100 pounds of weight, ten seconds of time and one nautical mile of distance.



## B. PERFORMANCE CHART REDUCTION

The reduction of the NATOPS Manual performance curves into analytical expressions was accomplished by a historically proven mathematical procedure, "least squares curve fitting". This method was applied to certain A-7E performance data by LCDR W.M. Siegel (see Introduction, Section I). His brief explanation of the "Least Squares Fit Approximation (LSFA)" is included in Appendix A.

Many performance charts from the NATOPS Manual contain three variables (two independent, one dependent) and are depicted as a two-dimensional space with the third dimension illustrated by a family of curves. The reduction of such a chart can be accomplished as follows:

1. Determine order of curves in family (i.e, second order,  $(y = A_1 + A_2x + A_3x^2)$ ).

2. Apply LSFA to every member of the family of curves.

3. Since the order of the curve families may vary, a general curve family could be depicted as follows:

$$y = A_{11} + A_{12}x + A_{13}x^2 + \dots A_{1m}x^{n-1} \quad (\text{for curve } z_1)$$

$$y = A_{21} + A_{22}x + A_{23}x^2 + \dots A_{2n}x^{n-1} \quad (\text{for curve } z_2)$$

$$y = A_{m1} + A_{m2}x + A_{m3}x^2 + \dots A_{mn}x^{n-1} \quad (\text{for curve } z_m)$$

4. Apply LSFA to the coefficients. For example, plot  $A_{11}$ ,  $A_{21}, \dots, A_{m1}$  versus  $z_1, z_2, \dots, z_m$ , respectively, yielding

$$A_1 = B_{11} + B_{12}z + B_{13}z^2 + \dots B_{1r}z^{r-1}.$$

Doing the same with all coefficients,



$$\begin{aligned} A_2 &= B_{21} + B_{22}z + B_{23}z^2 + \dots B_{2r}z^{r-1} \\ A_n &= B_{n1} + B_{n2}z + B_{n3}z^2 + \dots B_{nr}z^{r-1} \end{aligned}$$

5. Given  $z$  and  $x$ ,  $y$  can now be calculated by:

a. Computing coefficients from equations generated in

Step 4.

b. Applying coefficients to  $y = A_1 + A_2x + \dots A_nx^{n-1}$ .

6. It is important to note that although all curve family members must be of identical order, the equations representing the coefficients as a function of " $z$ " need not be of similar order.

Although applying LSFA to the family of curves and then to their coefficients was the normal method of chart reduction, it was not always used for the following reasons:

a. Some charts were two-dimensional (LSFA still used).

b. Some charts were reduced by inspection.

(1) Linear curve families with linear spacing.

(2) Time, distance, speed charts ( $d = v/t$ ).

c. Algorithm anomalies (see "Development Difficulties").

When used, the LSFA was accomplished by a program pre-written by the Hewlett Packard Corporation for use with the HP-9830. This program, although greatly facilitating the development portion of this investigation, was written for a two-dimensional problem and had to be executed at least once for each curve and once for each set of coefficients.

A listing of all of the equations making up the performance algorithms are contained in Appendix C. The A-7E



performance chart groups from which they were developed are contained in Appendix B. They are in order:

1. Low Level Cruise Performance.
2. Takeoff Ground Roll Distance.
3. Maximum Range Cruise Time and Speed at Constant Altitude.
4. Maximum Range Cruise Fuel Required at Constant Altitude.
5. Maximum Range Climb Airspeed Schedule.
6. Takeoff Airspeed.
7. Maximum Refusal Airspeed.
8. Optimum Endurance Altitude.
9. Cruise Ceiling.

Future reference in this thesis is made to algorithms and programs by the numbers above.

#### C. EXAMPLE OF CHART REDUCTION

An example of the procedure discussed in the previous section is presented below. The chart chosen for reduction is the lower graph of Figure 2, from Phase II of the A-7E Cruise Performance chart group.

By inspection, all  $A_1$  and  $A_2$  coefficients are equal to zero. The curves appear parabolic and therefore second order, yielding  $N = A_3 M^2$ . The example follows:

$N$  = intermediate result

$M$  = mach number

$D$  = drag count





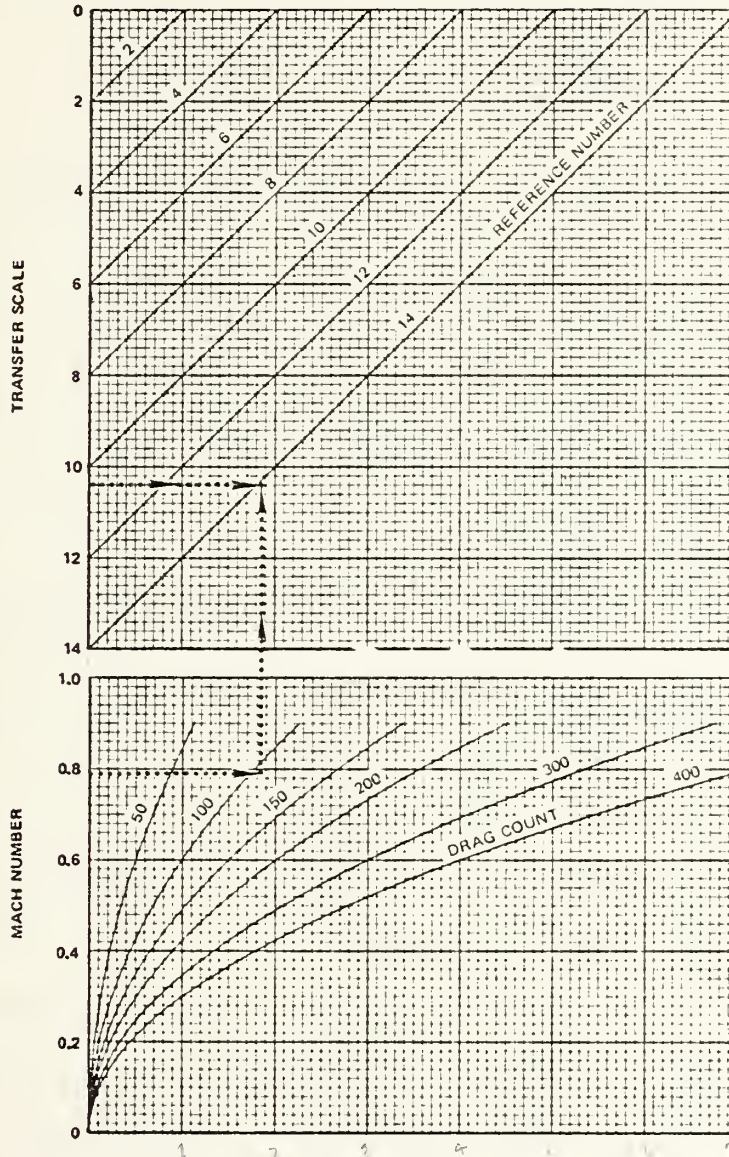
# CRUISE PERFORMANCE (A-7E)

11-117

## PHASE II - AIRCRAFT REFERENCE NUMBER

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



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11-58

Figure 2

Cruise Performance  
Phase II NATOPS Chart



<u>DRAG COUNT LINE</u>	<u>CURVE EQUATION</u>
50	$N = 1.3915M^2$
100	$N = 2.7787M^2$
150	$N = 4.1658M^2$
200	$N = 5.5530M^2$
300	$N = 8.3273M^2$
400	$N = 11.102M^2$

By plotting the  $A_3$  coefficients versus D (drag count), the LSFA yields:

$$A_3 = (4.3732E-3) + .027743D \text{ and therefore,}$$

$$N = ((4.3732E-3) + (.027743D))M^2.$$

This was a particularly simple chart to reduce but illustrates the procedure.

#### D. DEVELOPMENT DIFFICULTIES

The normal method of reducing performance curves did not always yield useful information. One reason was although the NATOPS Manual Performance curves were constructed from experimental data, families of curves occasionally had very unusual spacing. They also were not always a true curve family; that is, they were of varying order. This can be visually detected in the lower graph of Phase III of the A-7E Cruise Performance chart group (Figure 3). The unequal and varying spacing between curves with different "reference numbers" is obvious. Although the coefficients for each curve can be calculated, the coefficients determined for a LSFA equation for an intermediate curve would be incorrect. To be usable for the normal

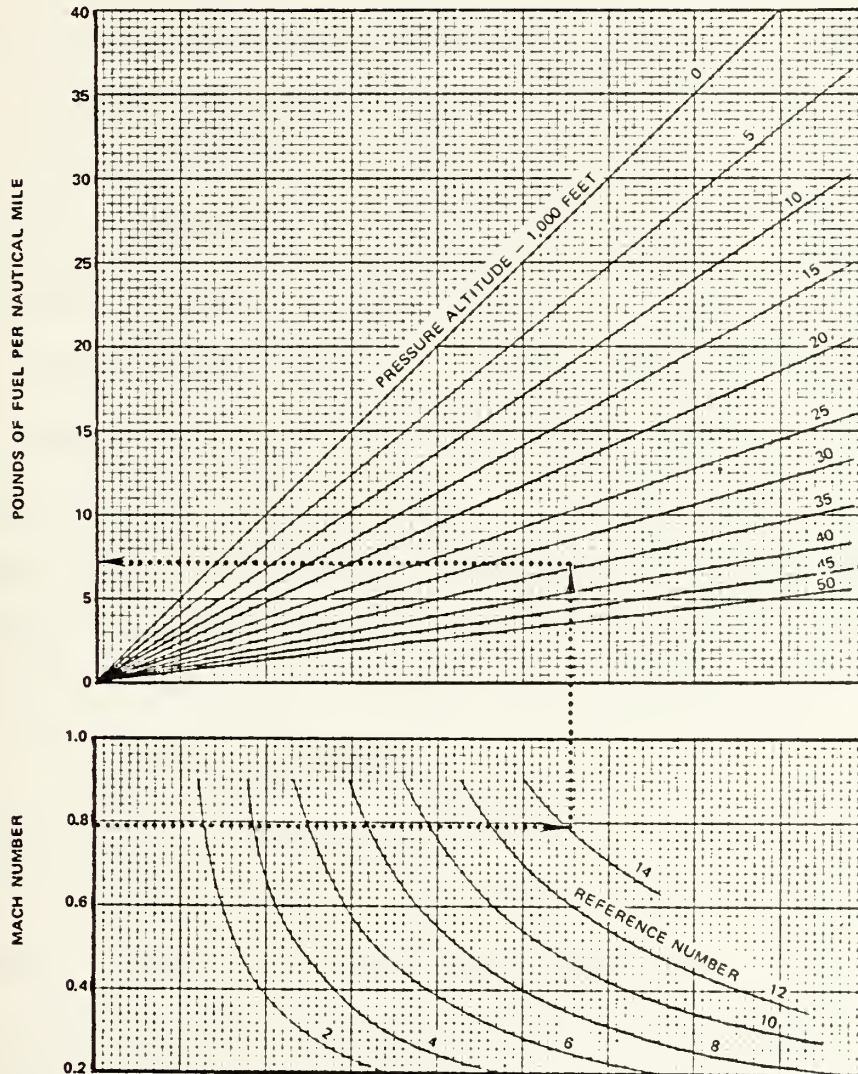


# CRUISE PERFORMANCE (A-7E)

## PHASE III - POUNDS OF FUEL PER NAUTICAL MILE

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



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Figure 3

11-59

Cruise Performance  
Phase III NATOPS Chart





method of chart reduction, a chart must have equal, constantly increasing, or constantly decreasing spacing between curves. When such an incompatible chart was encountered, it was necessary to interpolate between them. Two chart groups eliminated from consideration, "Fuel Required" and "Time to Climb from Sea Level to Selected Altitude", contained so many such curves (11), that very high order expressions would have been required to compute the coefficients, making implementation on the TI-59 HHC impractical. The A-7E Cruise Performance lower chart of Phase I had the same anomaly (Figure 4). Because of the importance of the low level mission, however, the algorithm for this chart was developed, for sea level only though. The multiple algorithm was not developed but could have been for implementation on a desk computer.

Another reason a straight application of LSFA was not always appropriate was the uniqueness of the upper graph of Phase I of the A-7E Cruise Performance chart group (Figure 4). This chart requires entry from the lower chart. A line is traced upward until the user contacts the appropriate Drag Count Line (dotted lines). The first pass through the Mach Number axis, a result of the lower chart, was defined  $M^*$ . Instead of now tracing horizontally to the Transfer Scale axis (this value defined  $TS^*$ ), one must trace "between the solid guidelines" to the interception with a line traced vertically upward from the desired Mach number,  $M$ . The Transfer Scale would now be manually obtained by tracing horizontally to the



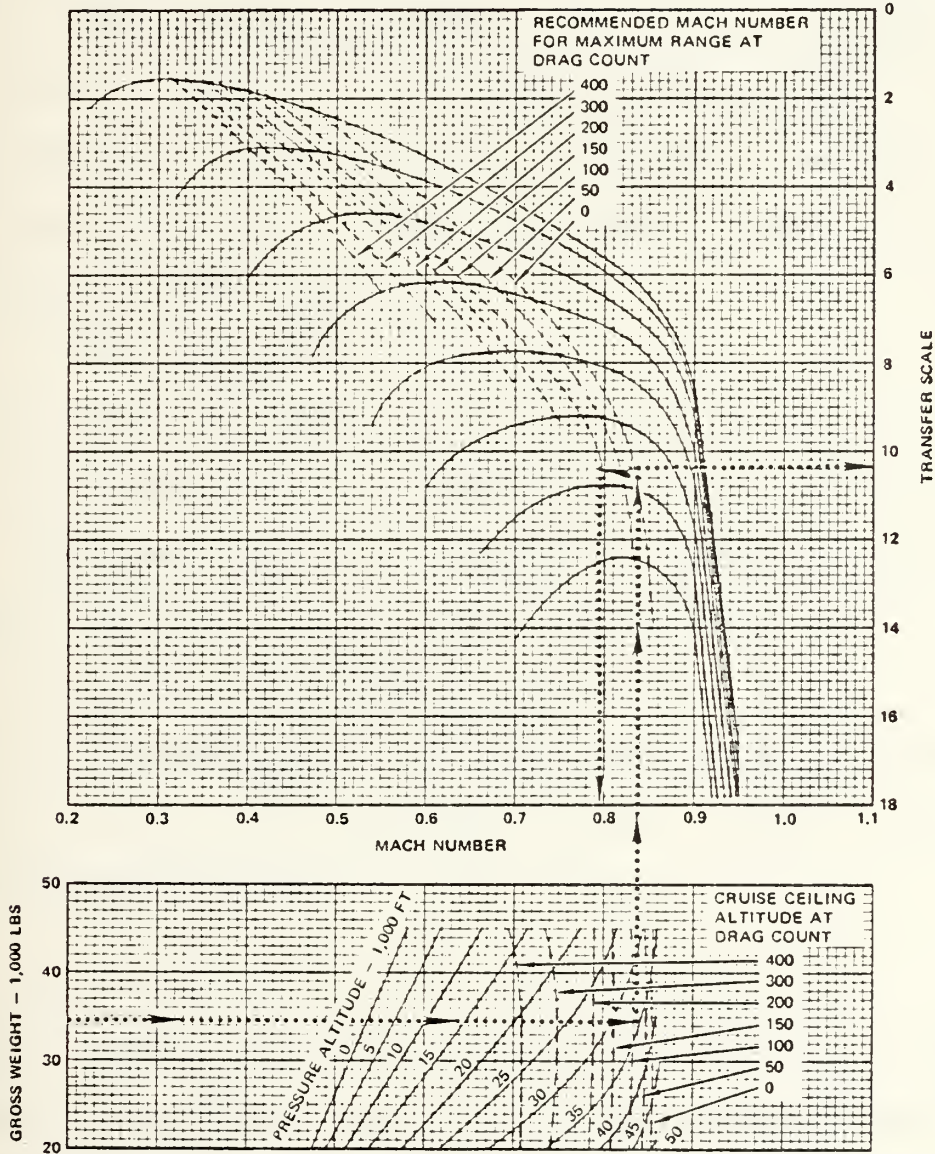


# CRUISE PERFORMANCE (A-7E)

## PHASE I - CLEAN AIRPLANE TRANSFER SCALE

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



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Figure 4

11-57

Cruise Performance  
Phase I NATOPS Chart



vertical axis. To develop the algorithm for this problem, the equations of the guidelines were also calculated as a function of Mach number. The values of the Transfer Scale resulting from  $M^*$  intercepting the guidelines and tracing horizontally to the vertical axis were called  $TS_1^*$ ,  $TS_2^*$ , ...,  $TS_m^*$ , from top to bottom. The original position,  $(M^*, TS^*)$ , could now be determined in relation to  $(M^*, TS_n^*)$  and  $(M^*, TS_{n+1}^*)$ . "n" and "n+1" indicate the upper and lower guidelines, respectively, which bracket  $(M^*, TS^*)$ . This ratio provided the initial position relative to the guidelines:

$$R = (TS^* - TS_{n+1}^*) / (TS_n^* - TS_{n+1}^*)$$

Using the desired Mach number,  $M$ , the Transfer Scales for the same two enclosing guidelines were calculated ( $TS_n$  and  $TS_{n+1}$ ). The final position relative to the guidelines was maintained using the original ratio by solving:

$$R = (x - TS_{n+1}) / (TS_n - TS_{n+1}) \text{ for } x.$$

"x" is the Transfer Scale with which the user now proceeds to Phase III of this performance chart group. Figure 5 depicts this problem graphically.

#### E. ACCURACY

A large number of results comparisons between the generated algorithms and manually traced performance problems were made. An infinite number of comparisons would be required to check all possibilities, but since the mathematical theory was so basic, the number of checks accomplished were considered sufficient.



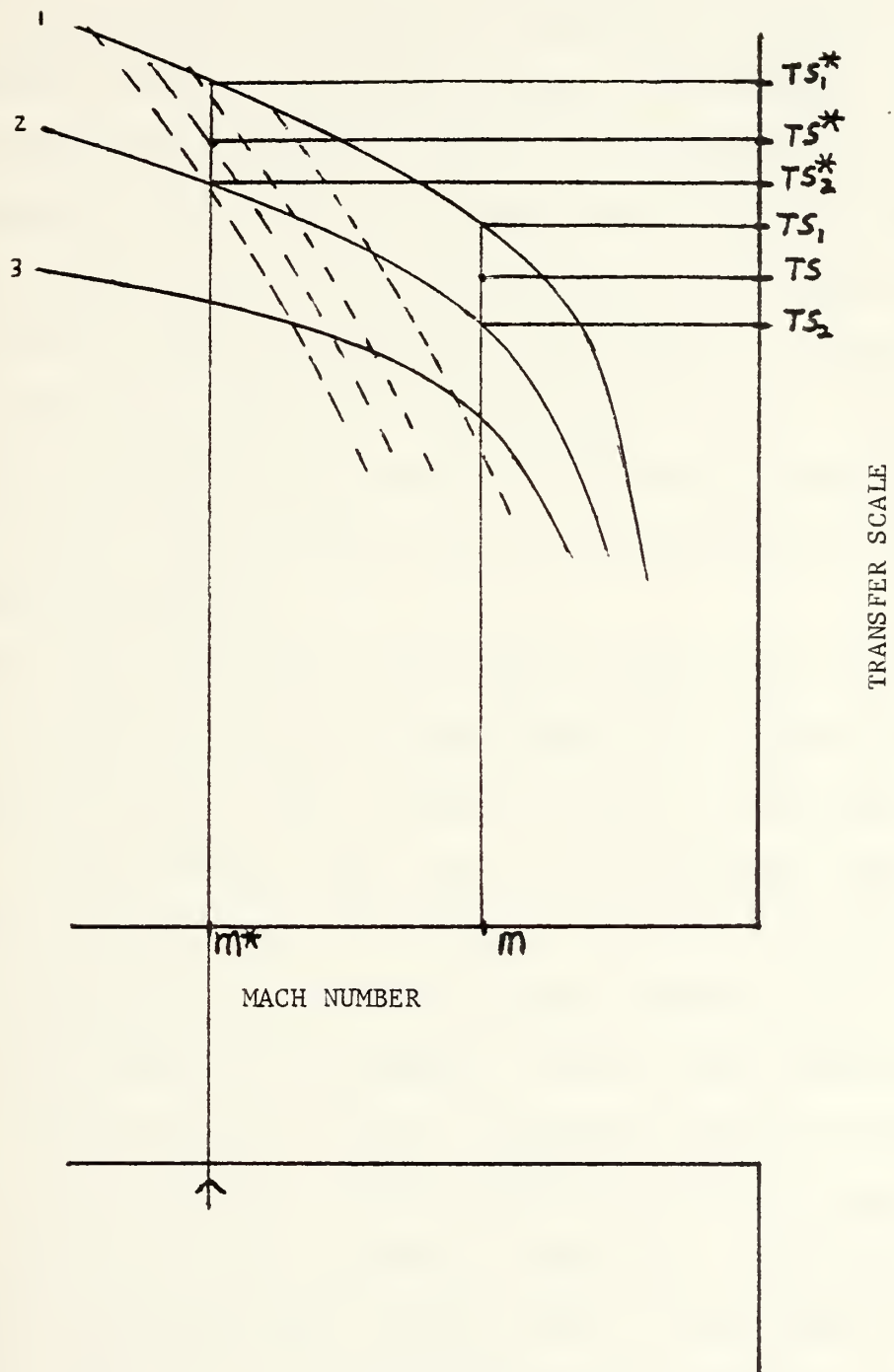


Figure 5  
Guideline Chart Solution



All nine algorithms were checked for accuracy on the HP-9830 desk computer. The number of checks for each algorithm was proportional to the ease of manually tracing through the performance charts. The author spent considerable time obtaining performance results from the NATOPS Manual charts and a relatively small amount of time computing the problems on the desk computer once the algorithms had been implemented. In a significant number of instances, the results disagreed, but after rechecking, the solution obtained manually was in error. This supported the contention that manual manipulation of the performance charts is an error prone procedure, even with an experienced user.

In a few rare instances, the author entered the required given data incorrectly into the desk computer. These miskeying errors, not procedural, were noticed as soon as the answer was produced. A user familiar with the A-7E performance characteristics would normally notice an answer resulting from grossly incorrect data input. It is acknowledged, however, that there is no failsafe check on the programs. When using a desk computer, the required input data can be printed along with the answer to ensure the user of the correctness of the input data. For a hand held calculator, however, computing a performance problem twice would provide a check, which is what many NATOPS Manual users often do. As with all computer programs, a desired result requires accurate input data.





Except for those noted below, the results of programs checked (using five significant figures) were indistinguishable from the answers obtained by manually manipulating the performance charts. Answers produced from the algorithms were rounded off to the nearest digit.

<u>PROGRAM</u>	<u>MAXIMUM DEVIATION</u>
Maximum Refusal Speed	2 knots
Takeoff Airspeed	1 knot



### III. IMPLEMENTATION

#### A. DESK COMPUTER

The use of a desk computer capable of producing A-7E performance information within seconds (less than three seconds computation time for the longest algorithm) would be ideal for a squadron briefing room or Air Operations Center use. The HP-9830 desk computer was used for this implementation stage. Very little training would be required for personnel to load the programs stored on a cassette tape cartridge and execute them.

A knowledge of "basic" computer language is required to fully understand the nine HP-9830 programs in Appendix D [4]. The nine programs are in the same order as the algorithms of Appendix C.

Only in the Low Level Cruise Performance program are sub-routines required for linear interpolation or for the iterative method to find the Transfer Scale (see "Development Difficulties"). All other programs are straight forward, sequential computations. In these programs, the coefficients defining a curve ( $y = f(x)$ ) for a given set of conditions are calculated. That chart result, "y", is then calculated for the given independent variable "x". The next chart of that group is similarly treated and so on until the "final result" is achieved.

The HP-9830 programs are very useful since they prompt the user to supply the correct information. Most of the programs



"request, then accept" those inputs required for the applicable NATOPS Manual performance chart. The HP-9830 then prints the data just entered (ensuring the user that data input was as desired) followed quickly by the solution. The computer is instantly ready to receive new data for another calculation.

Programs 1, 2, 3, 4 and 7 (as identified in "Performance Chart Reduction, section II-B), are written in this "request, then accept" format. The shorter programs, 5, 6, 8 and 9, were written with an initial set of input data already in the program. This format allowed the computer to step incrementally through the allowable range of values for the input data, thus calculating a "table of performance data" for the applicable performance chart group. These programs are easily altered to the "request, then accept" format by some simple edit commands [4].

The variables used in the programs are defined following each program in Appendix D.

## B. HAND HELD CALCULATOR

The many favorable features of the hand held calculator encouraged its implementation of the performance algorithms. Its small size allowed consideration for use in the cockpit. Its simplicity and reliability was an advantage making it especially suited for users of varying experience (including no experience). Although its execution speed was the slowest of all devices used, the computation time was still much faster than using the NATOPS Manual.



The Texas Instruments-59 (TI-59) programmable hand held calculator (HHC) was selected for implementation. This selection was made for several reasons. At the time, it was the only calculator available to the author which allowed permanent program storage (on magnetic cards). Additionally, the Texas Instruments Corporation had the capability to combine all pre-written performance programs, up to a 5000 program step limit, onto a Continuous Read Only Memory (CROM) chip, making the A-7E performance programs a permanent part of the calculator. This CROM chip can also be used on the less expensive TI-58 HHC. These features made the TI-58/59 (with CROM) a practical system for the A-7E Naval Aviation community.

One might consider the calculator's inability to prompt the user for inputs a shortcoming of this implementation candidate, but a company spokesman, Mr. Richard Cuthbert, stated a new face could be fitted onto the calculator, identifying different buttons with the input data categories such as GW for gross weight, FLPS for flap position, T( $^{\circ}$ C) for temperature, and so on [3].

Some time was required for the author familiarization with the TI-59 HHC and its capabilities. For a detailed explanation of comments in this section involving TI-59 programming and Appendix E, consult the user's manual [5].

All programs were entered with the calculator memory partitioned to allow 879 program steps and ten memory storage locations. The loss of program steps in order to provide coefficient storage locations (ten to one) was the reason for





partitioning in this manner. Only five significant figures were considered necessary for computational accuracy. Considering the number possibilities (1.2345 to 1.2345E-12) might take from six to ten program steps, this was less than the absolute ten program steps sacrificed for a storage location. The ten memory storage locations were used to store the input data at program execution start but were often reused after the input data storage was no longer required.

The programming language level of the TI-59 HHC is below the HP-9830's and above a microprocessor's (discussed later) in sophistication. The algorithms were computed in a more space-saving manner than on the HP-9830. For example, in computing a first order polynomial, the HP-9830 program functioned as follows:

$$B(0) = A_{11} + A_{12}z$$

$$B(1) = A_{21} + A_{22}z$$

$$y = B(0) + B(1)x.$$

The TI-59 HHC was programmed to compute as follows:

$$(A_{11} + A_{12}z) + (A_{21} + A_{22}z)x = y.$$

In the Low Level Cruise Performance program, the linear interpolation and iterative methods to follow guidelines (discussed in previous section) was still accomplished using the more tedious TI-59 HHC language.

Using the partitioning already described, a program limit of 879 program steps was imposed (filling two magnetic cards). Two programs, "Takeoff Ground Roll Distance" and "Low Level



Cruise Performance", exceeded this limit and had to be continued on extra cards. These programs were written to allow storage of an intermediate result into the T-register. The rest of the cards could then be read in, any lost or newly acquired input data entered, and program execution would continue, automatically retrieving the stored intermediate result from the T-register. These artificial necessities for program completion using the magnetic cards would not be necessary if the programs were stored permanently in the CROM.

The total number of steps required for the nine performance algorithms programmed on the TI-59 HHC was 5461 steps. By sub-routining (340 steps of programming are common to two programs), the total number could be reduced to 5121 steps. The elimination of the artificial steps required for the oversized programs would reduce the overage more. The sole intent of this implementation phase was not to fit these nine programs into the 5000 step CROM. If the inclusion of all nine programs was desired, streamlining aid offered by engineers from the Texas Instruments Corporation plus the reduction of significant figures in a non-critical area would accomplish this.

The program listings, storage location usage, user instructions, and execution times are included in Appendix E.

## C. MICROPROCESSOR

### 1. Single Board Computer using Software for Mathematical Operations

The single board computer (SBC) implementation was investigated both as an extension of thesis work and to meet



the course objectives of AE-4900, Air Data Systems. Work toward this effort was also done by LCDR W.M. Siegel. The performance algorithms were to be processed on a SBC using an INTEL Corporation 8048 Programmable Read Only Memory (PROM), external random access memory (RAM) and a program counter. Software development was completed on the INTEL Prompt-48 (Microcomputer System-48 language) using an INTEL 8035 arithmetic logic unit (ALU). Although a SBC using the 8048 PROM and requiring a digital keyboard and display was never actually constructed because of the time limitations, the software operation was successfully demonstrated on the Prompt-48.

To preserve the programs between operation periods, the Prompt 48 was hand wired as specified in the user's manual to an ASR-35 Teletype set which allowed paper tape storage [6]. The Prompt-48 provided 1024 by two bytes of RAM and 64 by two bytes of resident memory. Although the MCS-48 instruction set will not be discussed in this thesis, a basic understanding of assembly level language is necessary to understand the developed software presented in Appendix F [7]. This microprocessor program listing includes the MCS-48 instructions in hex code and literal mnemonics and includes full documentation to facilitate interpretation.

A full performance algorithm was not implemented on the Prompt-48 because of its memory storage limitations. The original intent was to exercise the software of the complete A-7E Takeoff Ground Roll Distance algorithm on the Prompt-48.



After the necessary routines were written and stored, only room for three coefficients remained (98 coefficients required for this algorithm). Since implementation capability was the desired result, the computation of a second order polynomial was considered sufficient. Although this effort was software oriented, the necessary RAM storage for the additional coefficients and executive routine could have been easily provided for a SBC.

The software development for algorithm implementation required routines for input/output (I/O), executive direction, binary to binary coded decimal (BCD) and BCD to binary conversions, and floating point binary addition and multiplication routines. The I/O and executive routines were written by LCDR Siegel. The nonavailability of a number oriented microprocessor at the time of this effort required the development of the mathematical package described above. The advantages for such a capability will be discussed in the following section.

In addition to the microprocessor software developed by the author and LCDR Siegel, the I/O and display routines would require alteration for SBC implementation since a digital display and keyboard would replace the Prompt-48.

Figure 6 illustrates the solution method. Figure 7 is a flow chart of the program execution sequence. Figures 8 and 9 show the Prompt-48 RAM and resident register memory, respectively.





# SBC SOLUTION METHOD

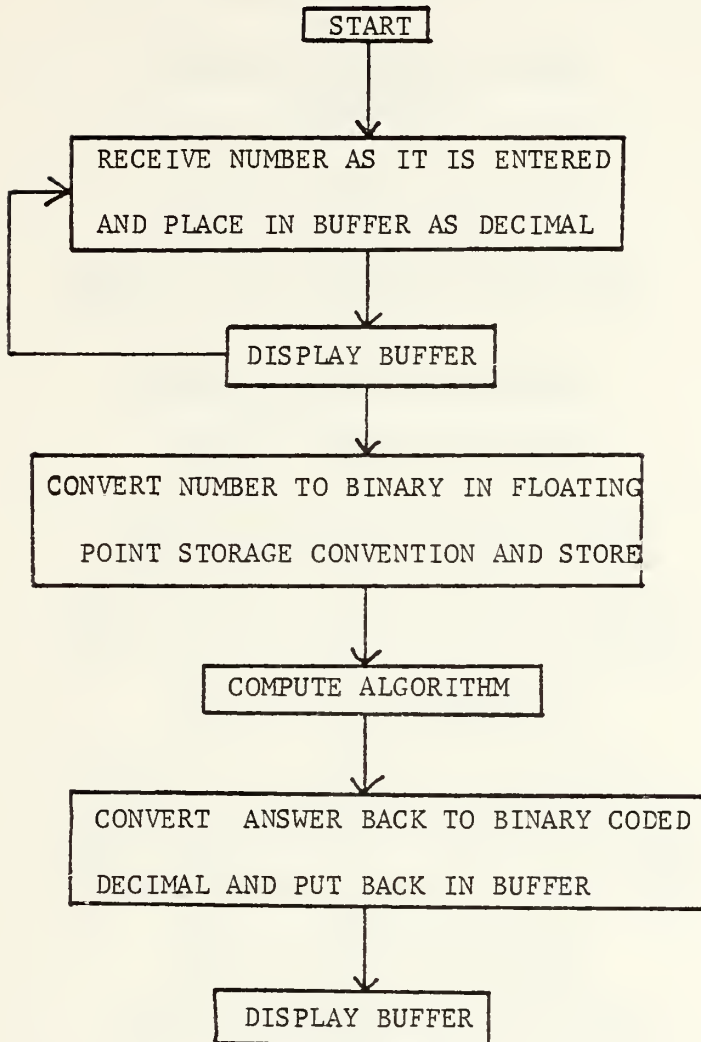


Figure 6

SBC Solution Method



SBC PROGRAM EXECUTION SEQUENCE

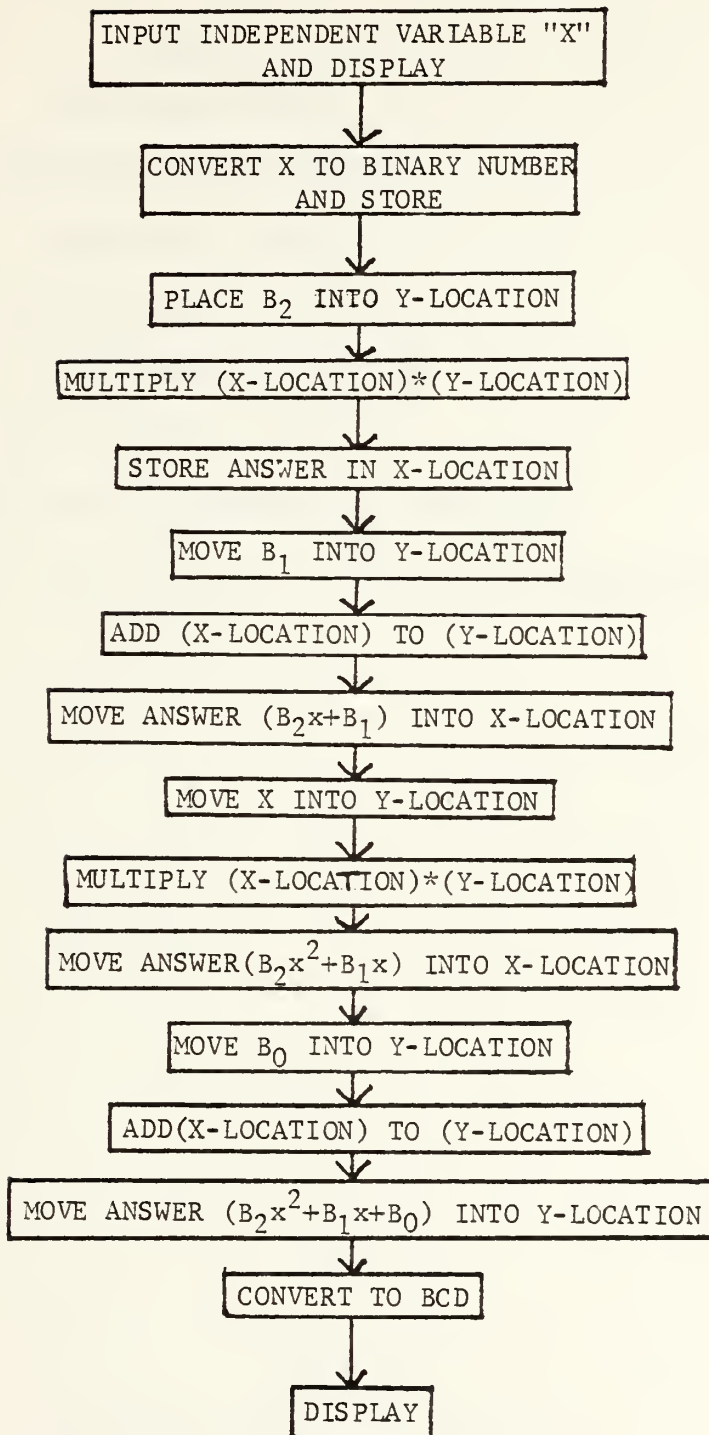


Figure 7

SBC Program Execution Sequence



RANDOM ACCESS MEMORY MAP

<u>ADDRESS</u>	<u>USE</u>
000-069	INPUT AND DISPLAY
06A-06F	EXECUTIVE ROUTINE SEGMENT
Q70-079	COEFFICIENT STORAGE
07A-0C6	MAIN EXECUTIVE ROUTINE
0C8-0E2	BINARY TO BCD EXECUTIVE ROUTINE
0E5-0FF	MISCELLANEOUS SUBROUTINES
100-2EC	ADDITION AND MULTIPLICATION SUBROUTINES
300-3FF	BCD TO BINARY EXECUTIVE ROUTINE AND CONVERSION SUBROUTINES

Figure 8  
Random Access Memory Map



# RESIDENT REGISTER MAP

ADDRESS	USE	ADDRESS	USE
20	LSB	30	
21	X-LOCATION	31	
22	ARITHMETIC REGISTER	32	LSB
23	MSB	33	DISPLAY HEX
24	EXPONENT	34	BUFFER
25	LSB Y-LOCATION	35	MSB
26	MSB ARITHMETIC REGISTER	36	DECIMAL POINT MASK
27	EXPONENT	37	CHARACTER COUNTER
28	LSB BCD-BINARY	38	LSB
29	MSB CONVERSION	39	
2A	EXPONENT	3A	DISPLAY
2B		3B	
2C		3C	BIT
2D		3D	
2E		3E	PATTERNS
2F		3F	MSB

Figure 9

Resident Register Map





The second order polynomial,  $y = B(0) + B(1)x + B(2)x^2$ , was calculated using a mathematical executive routine (alterable for any size polynomial and any number of polynomials). The only mathematical operations required were multiplication and addition of positive or negative numbers. For speed, binary arithmetic was used. For increased storage capability and mathematical efficiency, a floating point capability was included.

The calculation routine proceeded as follows:

$$B_2 * x = (B_2 x)$$

$$(B_2 x) + (B_1) = (B_2 x + B_1)$$

$$(B_2 x + B_1) * x = (B_2 x^2 + B_1 x)$$

$$(B_2 x^2 + B_1 x) + B_0 = (B_2 x^2 + B_1 x + B_0)$$

Although all mathematical operations are performed in the 8-bit (2-byte) accumulator register of the 8035 ALU (for a SBC, the 8048 PROM), a working accumulator using five registers (resident memory registers two through six), was established. All numbers in the program (independent variable "x" after conversion to binary, coefficients stored in RAM 070-079 and the 'result') were in one of two binary conventions. While in storage, the numbers were in "storage" convention. The numbers were shifted from "storage" to "working" convention only when transferred from the X and Y locations (see resident register memory map, Figure 9) to the working accumulator (registers two through six). When the desired operation was completed, the result was returned to the "storage" convention



and moved to the "X" location. Figure 10 displays the "storage and working" conventions.

This software was successfully demonstrated on the Prompt-48. The user instructions for the Prompt-48 to repeat the demonstration are listed below:

(1) Ensure the 8035 ALU or 8048 PROM is inserted in the "execution" socket of the Prompt-48.

(2) Enter the program in hex code in the proper storage locations as listed in Appendix F.

On the Prompt-48, press the following keys to clear the resident register memory:

"C"

"Registers"

"0"

","

"4"

"8"

Do not press "Program Memory" instead of "registers" or the program just entered will be erased.

(3) To execute the program, press the following keys:

"A"

"2"

"Execute"

"Go"

"No Break"

"0"

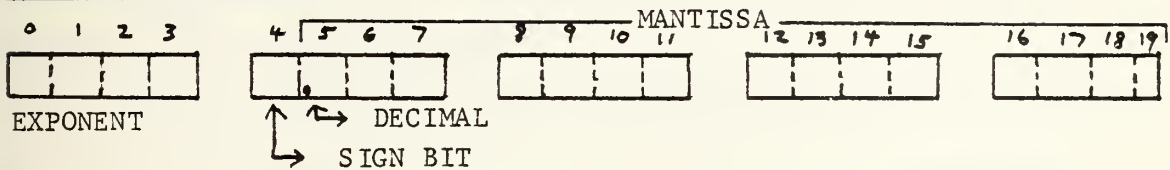
"Execute"



## BINARY CONVENTIONS

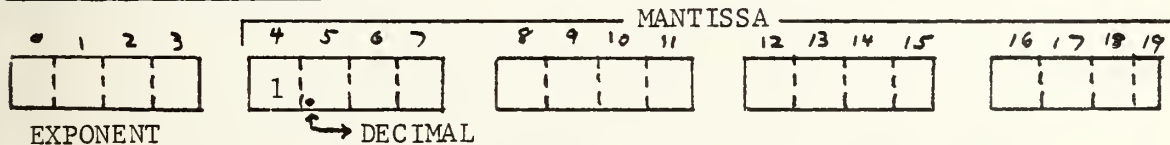
Each large block depicts 1 byte which includes 4 bits. The compartmented blocks represent 1 bit.

### STORAGE CONVENTION



In storage convention, the mantissa is left justified to bit 5. A positive number is denoted by 0 in the first bit of the second byte(sign bit); a 1 indicates a negative number.

### WORKING CONVENTION



In working convention, the mantissa is left justified to bit 4. The sign bit is stored in F0(X-location number) and F1(Y-location number) flags of the program status word.

Figure 10  
Binary Conventions



The display will blank, awaiting the input of the independent variable "x". To enter "x", enter the digit keys for numbers (base 10) and "D" for decimal point. "x" will be displayed on the digital display as it is entered. To compute the algorithm (second order polynomial), press "E". The answer will rapidly appear. To calculate the polynomial with a new value for "x", start at Step 3.

(4) To prevent the time consuming reloading of the program, it is advisable to store the program on a peripheral device (paper tape, disc, etc.).

## 2. Single Board Computer using Number Oriented Microprocessor

Very recently, the National Semiconductor Corporation began production of a chip intended for use in number processing applications [8]. This chip, the MM57109 MOS/LSI, is capable of all scientific calculator functions, test and branch capabilities, internal number storage, and I/O instructions. Of the specific calculator functions, only addition, subtraction and multiplication would be used.

A SBC using this chip would need the 8048 PROM for coefficient and executive routine storage but would not need the space consuming mathematical package of the SBC in the last section. A program counter would still be required but external RAM would not. The computation time would be increased over the demonstrated SBC (approximate computation time of a HHC), but the simplicity of programming would make this proposed SBC very attractive.





#### D. A-7E TACTICAL COMPUTER

In February 1978 the author made a trip to the Naval Air Facility at China Lake, California. The purpose of this visit was to receive indoctrination on the TC-2/2A tactical computers and obtain a programming manual for these devices. The desired goal was implementation of selected performance algorithms on the laboratory bench computer run by the A-7 Program Office of the Naval Weapons Center (NWC). A thorough understanding of the computer's capabilities and limitations was provided by Mr. Robert Westbrook, a software technician.

The A-7E computer provides very accurate navigation and weapons guidance capability. The TC-2 and TC-2A computers are a generation apart, the TC-2A being over two times faster and having twice the storage capability of its earlier version. Both computers are operational at this time. Specific design and programming information is available from the programming manual [9].

The instruction set of the tactical computer provides fixed point arithmetic, logical transfer of control (branching), address modification and single word input/output instructions specifically intended for operations primarily involving arithmetic. These features made the implementation of algorithms a logical decision. Several factors made this implementation by the author impractical. The computer design was quite old, the instruction set being very tedious and difficult to interpret. The computer's inability to function using floating point



arithmetic would require a significant software effort in that area alone. The time required to become fully familiar with the instruction set, write the software, and load and test the programs at NWC would have been prohibitive for this investigation.

It is hoped that the programmers at NWC will be able to implement those algorithms deemed desirable to achieve an onboard capability. Takeoff Airspeed and Maximum Refusal Airspeed are considered ideal for implementation.



#### IV. CONCLUSIONS AND RECOMMENDATIONS

Nine of the A-7E NATOPS Manual performance chart groups were reduced to a series of analytical expressions or algorithms. These algorithms, accurate to five significant figures, are as accurate as results obtained by manual manipulation of the performance charts.

Implementation was made on three data processors of different programming levels and storage capabilities. These devices and degrees of implementation were:

(1) HP-9830 Desk Computer - complete implementation with successful demonstration.

(2) TI-59 Hand Held Calculator - complete implementation with successful demonstration.

(3) Microprocessor - partial implementation with successful demonstration.

In view of the success of this investigation, recommendations concerning implementation possibilities are listed below:

(1) Complete reduction of the NATOPS Manual performance charts could be accomplished and implemented onto a desk computer as one large program capable of performance data computation within seconds. The desk computer would be ideal for mission planning on a squadron or air wing level or for Air Operations Center use.

(2) The programs written for the TI-59 HHC could be consolidated onto a CROM and used with a TI-58 HHC for use on a



squadron level. As an alternative, the software could be rewritten for any HHC of comparable capability.

(3) Although implementation on a single board computer using a number oriented microprocessor is completely feasible, because of programming ease and cost consideration, the HHC is considered a superior implementation possibility at this time.

(4) The A-7E tactical computer could easily be programmed by software engineers at NWC, China Lake, California, to produce an onboard capability.





## APPENDIX A

### Least Squares Fit Approximation

References 10 and 11 describe the Least Squares Fit Approximation in detail. In general the problem is to represent a set of "n" data points in two-dimensional space

$$X_i, Y_i \quad i = 1 \text{ to } n$$

by a polynomial expression of a curve whose degree is less than "n". Two classes of problems exist:

(1) Linearly independent - those in which the degree (d) of the polynomial is one less than the number of data points

$$d = n-1 \tag{1}$$

(2) Linearly dependent - those in which the degree (d) is less than n-1

$$d < n-1 \tag{2}$$

As an example, a set of four (4) data points randomly spaced was chosen. If a third degree polynomial of the form

$$Y = A + BX + CX^2 + DX^3 \tag{3}$$

were desired, and the data points  $X_i$  and  $Y_i$  were inserted ( $i = 1$  to 4) into four such equations, an exact solution for the four unknown coefficients would exist. These four unknowns could be found from the four equations by numerous conventional techniques (Direct substitution, Cramer's rule, etc.). The polynomial expression generated would be termed a "col-location" polynomial because its plot would pass through all data points.



It is often advantageous to describe a set of data points by a curve that does not pass through each point. This type of polynomial would be termed a "regression" equation. For any set of data points an infinite number of regression expressions exist for any specified degree (except the linearly independent case) and the object of the Least Squares Method is to find the polynomial coefficients of the chosen degree that best describe the data points. In the previous example of four data points, assume that, instead of the third degree form chosen, a second degree equation were selected of the form

$$Y = A + BX + CX^2 \quad (4)$$

With four data points, the polynomial is overspecified and thus linearly dependent. For this case an infinite number of solutions exist for the coefficients a, b and c. If an error term ( $\delta$ ) were defined for any given X,Y pair as

$$\delta_1 = |Y_1 - A + BX_1 + CX_1^2| \quad (5)$$

a total squared error term (E) could then be defined by squaring and summing the terms attained:

$$E = \sum_{i=1}^N \delta_i^2 \quad (6)$$

If E were then minimized for any given degree chosen, the best Least Squares Fit would have been achieved.

If the values for  $\delta$  from Equation 5 were inserted in Equation 6 and the partial derivative of E were taken with respect to the coefficient A, an equation would be generated that when set equal to zero (0) would define a minimum value of E for a given value of A. If the same operation were performed with respect to the



coefficients B and C then three equations would be generated with three unknowns (A, B and C). The solution of these simultaneous equations would produce the coefficients A, B and C, that would minimize the value of E and hence would produce a Least Squares Fit approximation to a set of linearly dependent equations.

A numerical procedure has been developed to accomplish this task. An example of this procedure has been included in the following paragraphs [10, 11].

#### Least Squares Fit Method Example

Given the following set of data:

X	0	1	2	4	7
f(X) = Y	0	1	3	12	20

fit a curve of the form

$$f(X) = Y = A + BX + CX^2$$

STEP 1: Substitute all pairs of data into the form equation yielding the fact that the coefficients (A, B and C) must satisfy all the following:

$$0 = A + B(0) + C(0)^2$$

$$1 = A + B(1) + C(1)^2$$

$$3 = A + B(2) + C(2)^2$$

$$12 = A + B(4) + C(4)^2$$

$$20 = A + B(7) + C(7)^2$$

Now multiply each expression by its coefficient of A in that expression and add all equation yielding



$$36 = 5A + 14B + 70C$$

Now multiply each expression by its coefficient of B in that expression and add all the equations yielding

$$0 = 0(A) + 0(B) + 0(C)$$

$$1 = A + 1B + 1C$$

$$6 = 2A + 4(B) + 8(C)$$

$$48 = 4A + 16(B) + 64(C)$$

$$140 = 7A + 44(B) + 343(C)$$


---

$$195 = 14A + 70(B) + 416(C)$$

Now multiply each expression by its coefficient C in that expression and add all the expressions yielding

$$0 = 0(A) + 0(B) + 0(C)$$

$$1 = 1(A) + 1(B) + 1(C)$$

$$12 = 4(A) + 8(B) + 16(C)$$

$$192 = 16(A) + 64(B) + 256(C)$$

$$980 = 49(A) + 343(B) + 2401(C)$$


---

$$1185 = 70A + 416B + 2674C$$

Now solve the following three previously generated equations for the coefficients A, B and C yielding

$$36 = 5A + 14B + 70C$$

$$195 = 14A + 70B + 416C$$

$$1185 = 70A + 416B + 2674C$$

$$A = -.99, B = 2.6, C = .065$$

and

$$Y = -.99 + 2.6X + .065X^2$$





The following plot and chart depict the original data and the data obtained from the equation for the fitted curve:

X	<u>Original</u>	<u>Fitted Curve</u> <u>Polynomial</u>
	Y	Y
0	0	-.98
1	1	1.67
2	3	4.48
4	12	10.46
7	20	20.41

Q.E.D.

.



## APPENDIX B

### NATOPS Manual Performance Charts

These charts from which the performance algorithms were developed are listed below in order:

<u>Figure</u>	<u>Title</u>
B1	Cruise Performance, Phase I
B2	Cruise Performance, Phase II
B3	Cruise Performance, Phase III
B4	Cruise Performance, Phase IV
B5	Takeoff Factor
B6	Takeoff Ground Roll Distance
B7	Adjusted Takeoff Ground Roll Distance
B8	Maximum Range Cruise at Constant Altitude (Time, Speed)
B9	Maximum Range Cruise at Constant Altitude (Fuel Required)
B10	Military Power Climb Schedule
B11	Takeoff Speed
B12	Maximum Refusal Speed
B13	Cruise Ceiling and Optimum Endurance Altitude

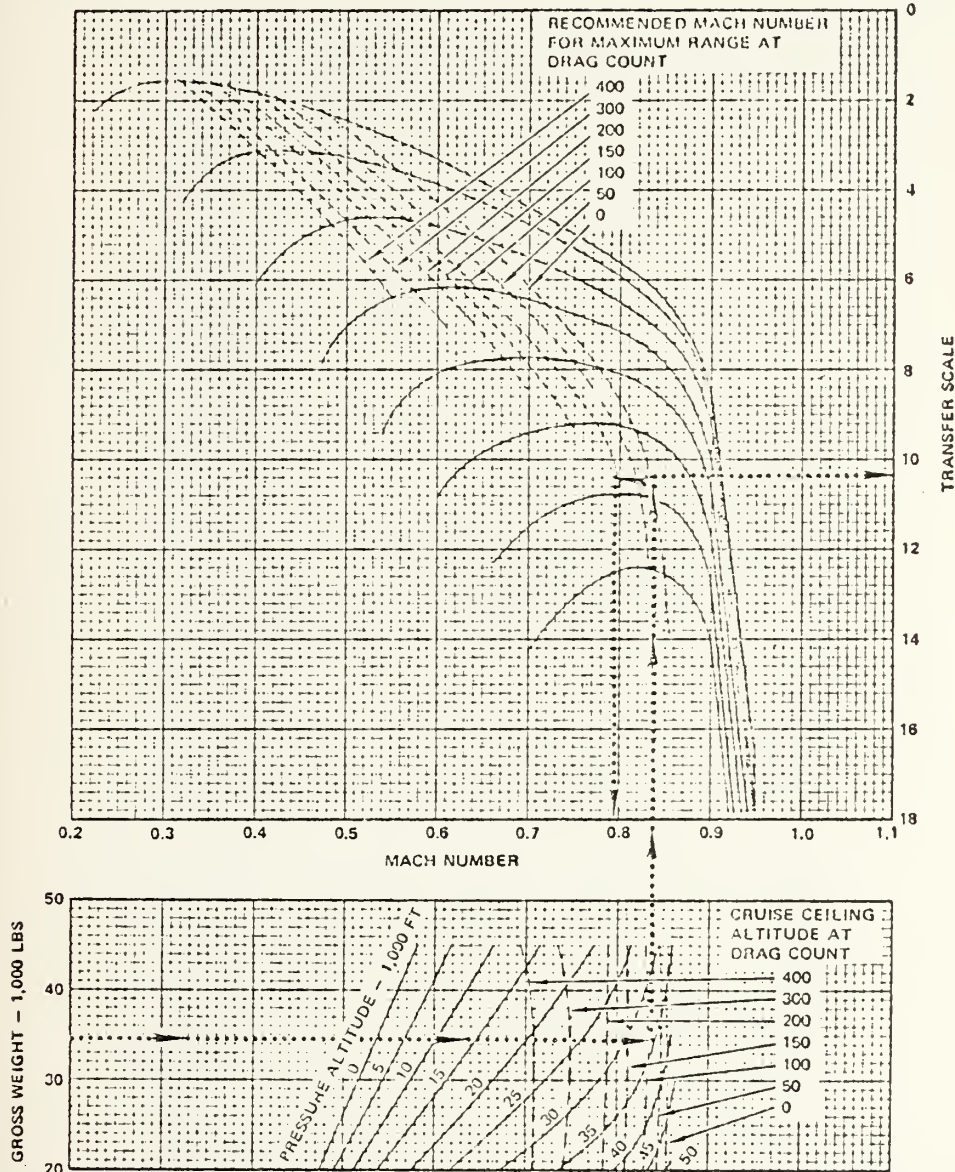


# CRUISE PERFORMANCE (A-7E)

## PHASE I - CLEAN AIRPLANE TRANSFER SCALE

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76E209 (1) -03-72

Figure B1

11-57

Cruise Performance, Phase I



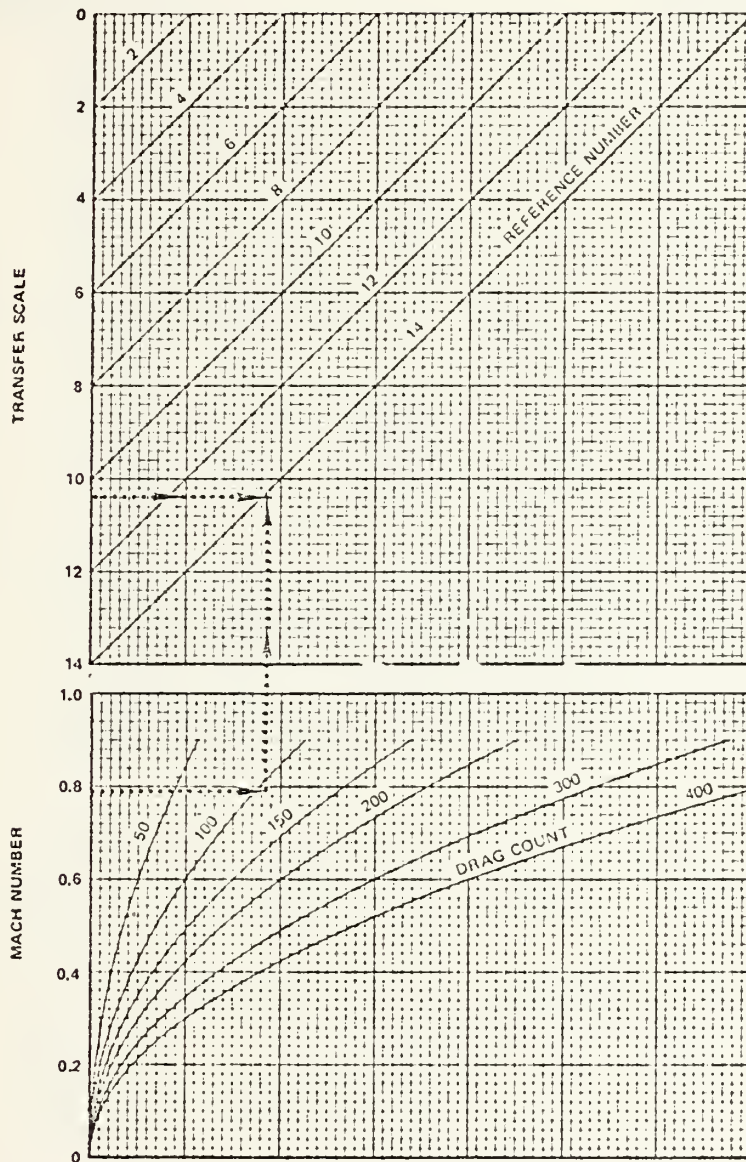
# CRUISE PERFORMANCE (A-7E)

## PHASE II - AIRCRAFT REFERENCE NUMBER

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

11-117

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76 F 269 (2) - 03 - 72

11-58

Figure B2

Cruise Performance, Phase II



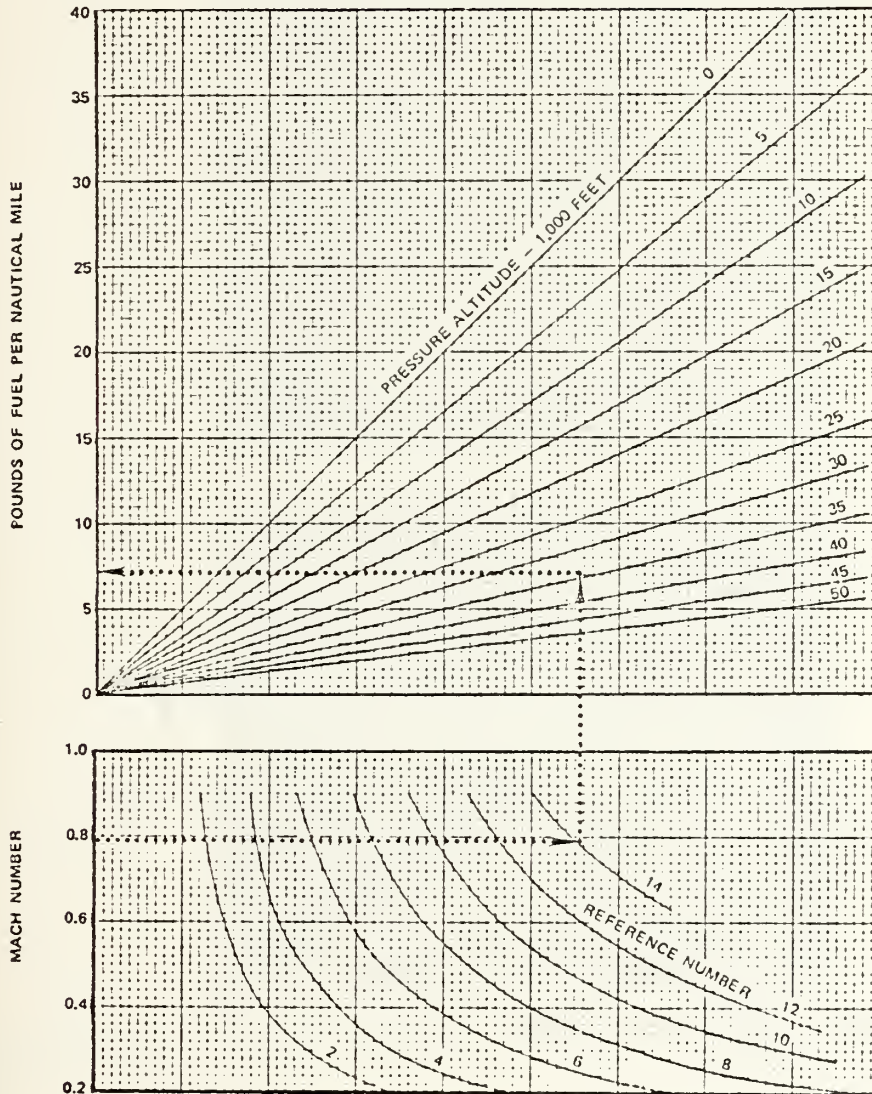


# CRUISE PERFORMANCE (A-7E)

## PHASE III - POUNDS OF FUEL PER NAUTICAL MILE

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76.F.769 (1) - 01 - 72

Figure B3

11-59

Cruise Performance, Phase III

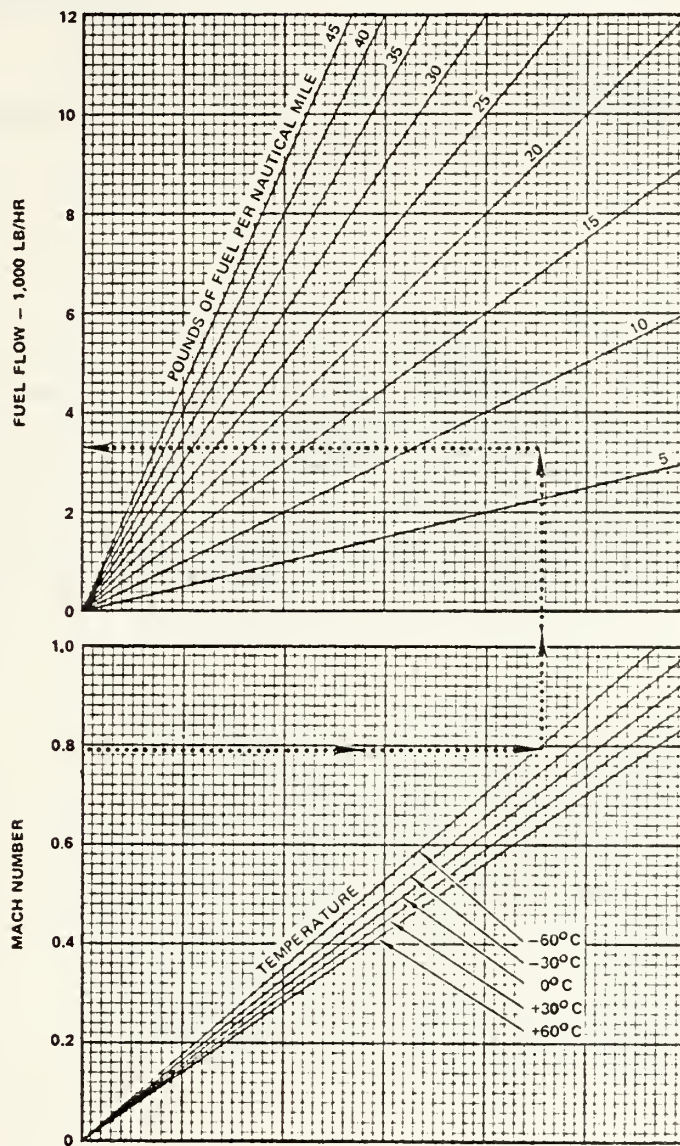


# CRUISE PERFORMANCE (A-7E)

## PHASE IV - FUEL FLOW

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76F269(4)-03-72

11-60

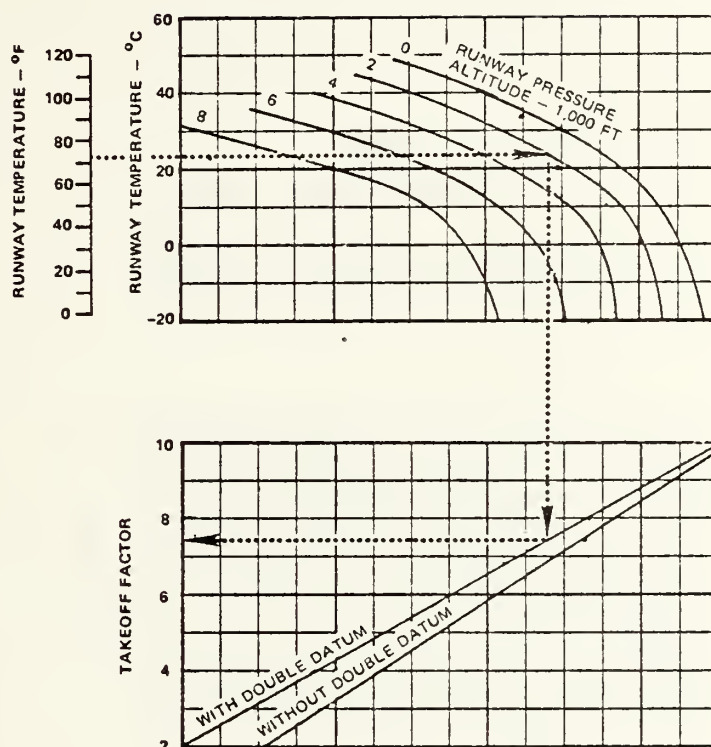
Figure B4  
Cruise Performance, Phase IV



# TAKEOFF FACTOR (A-7E)

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL.



76E286-04-74

Figure B5  
Takeoff Factor



# TAKEOFF GROUND ROLL DISTANCE (A-7E)

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

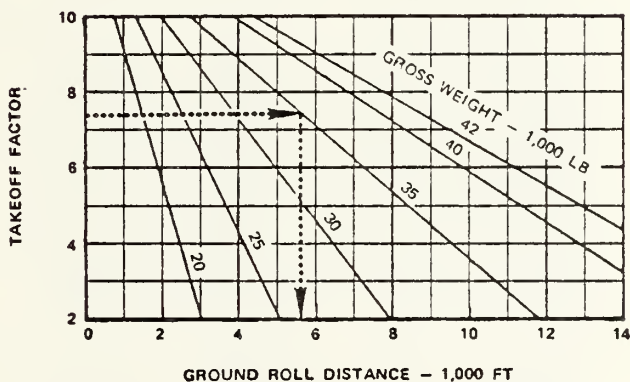
CONDITIONS:  
LEVEL HARD SURFACE RUNWAY  
MILITARY RATED THRUST  
LANDING CONFIGURATION  
ZERO HEADWIND  
CG: 26% MAC  
FULL FLAPS

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL

## NOTE

For minimum ground roll corresponding to minimum lift-off speed, subtract 500 feet.

For humidity effects on takeoff distance, ground roll distances should be increased 1% for each 10% increase in the relative humidity above 40%.



76E287(1)-04-74

Change 6

11-19'

Figure B6

Takeoff Ground Roll Distance





## TAKEOFF GROUND ROLL DISTANCE (A-7E)

### ADJUSTED GROUND ROLL DISTANCE

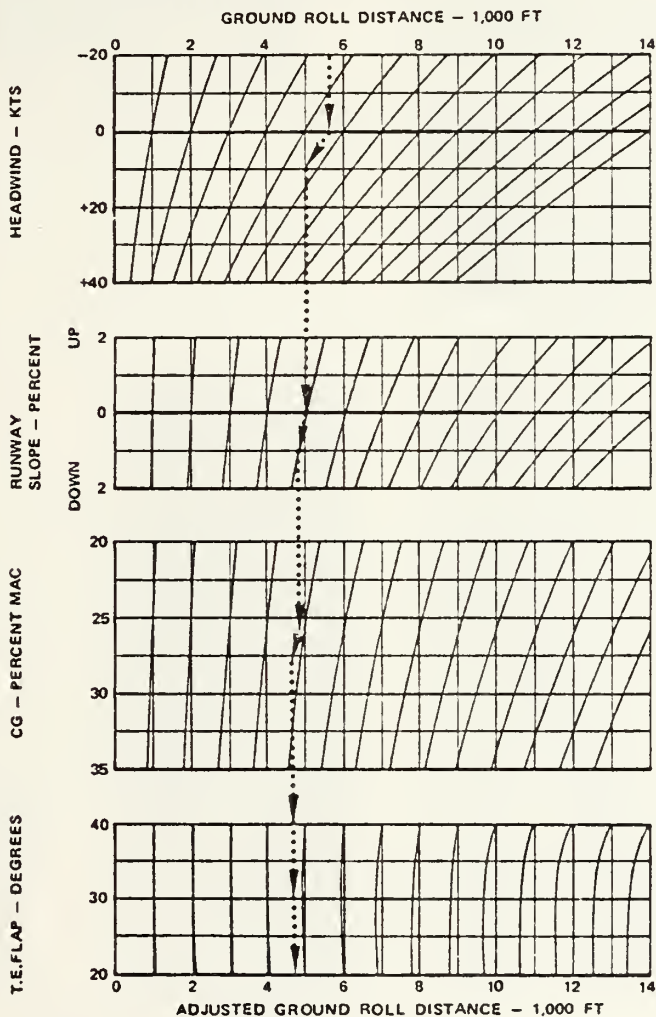
MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

CONDITIONS:  
HARD SURFACE RUNWAY  
MILITARY RATED THRUST  
LANDING CONFIGURATION  
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL

#### NOTE

For humidity effects on takeoff distance, ground roll distances should be increased 1% for each 10% increase in the relative humidity above 40%.



76E287(2)-02-72

Figure B7

Adjusted Takeoff Ground Roll Distance

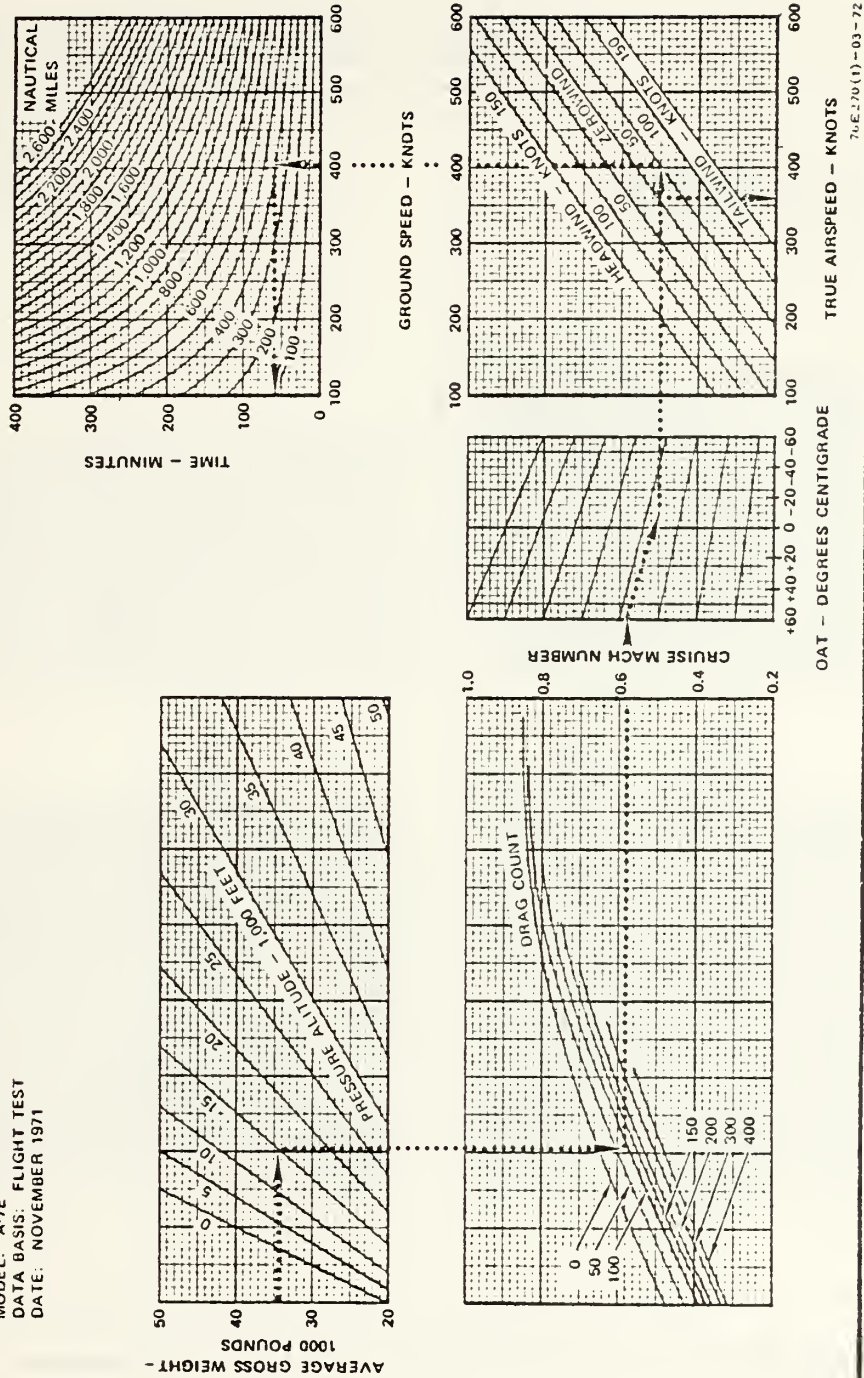


# MAXIMUM RANGE CRUISE AT CONSTANT ALTITUDE (A-7E)

## TIME AND SPEED

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



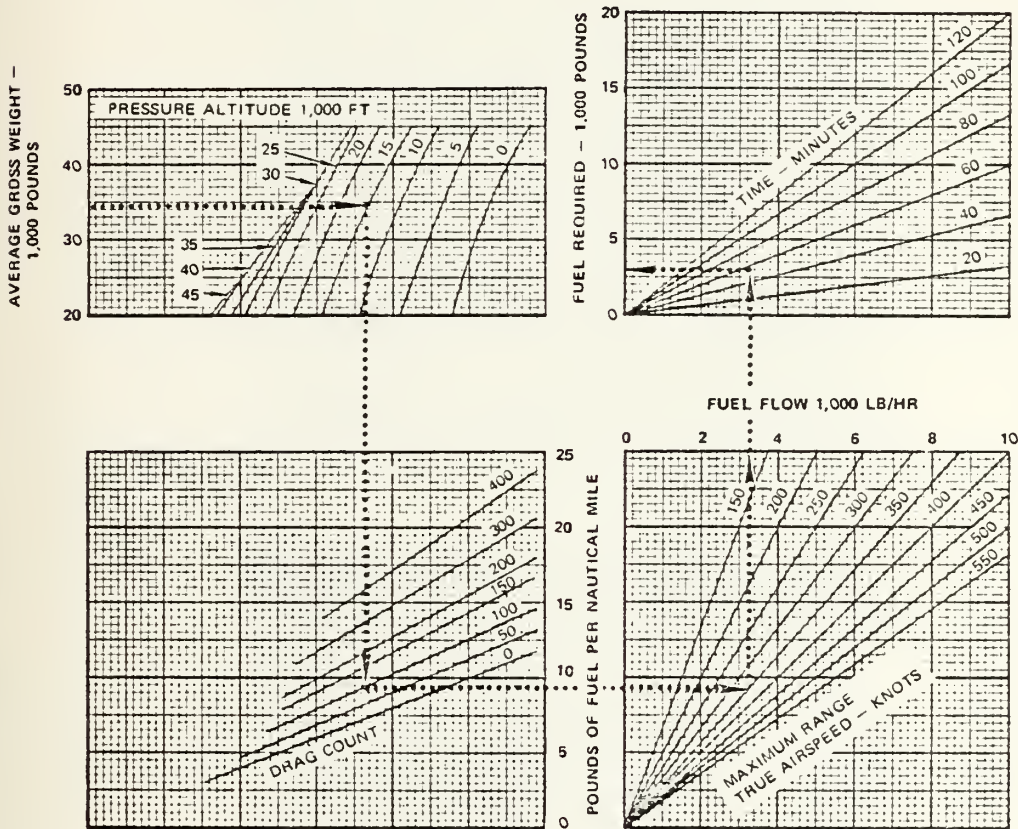


# MAXIMUM RANGE CRUISE AT CONSTANT ALTITUDE (A-7E)

## FUEL REQUIRED

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76E270(7)-03-72

Figure B9

11-63

Maximum Range Cruise at Constant Altitude (Fuel Required)



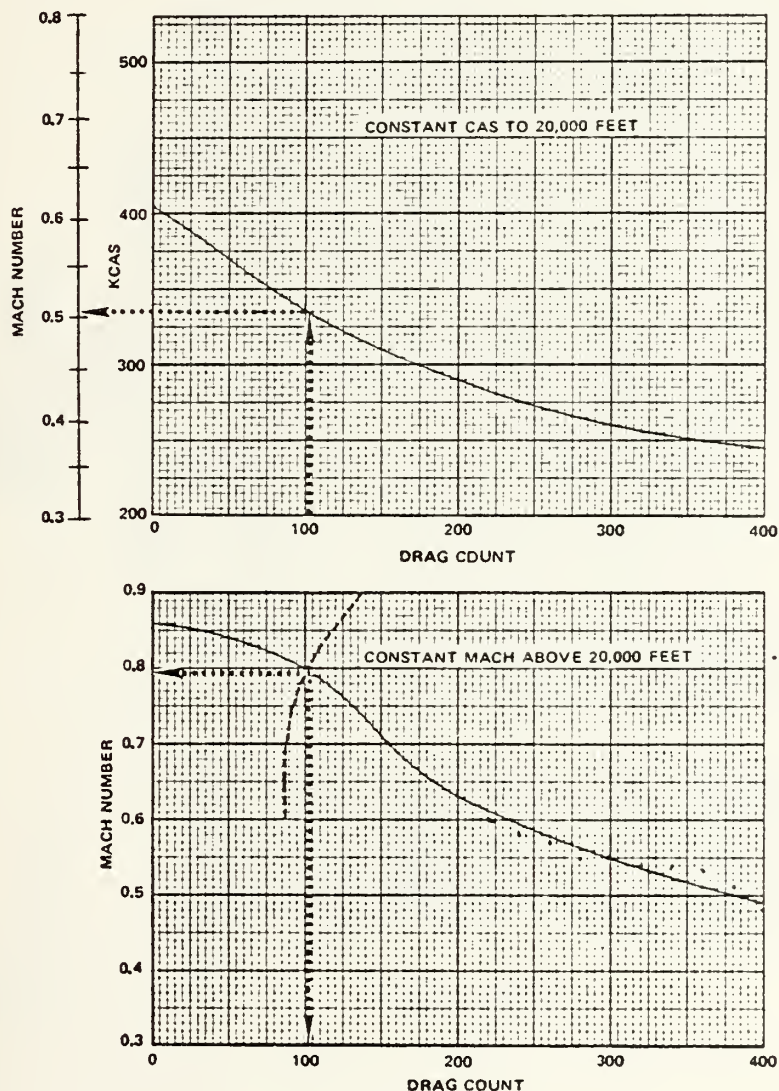


# MILITARY POWER CLIMB (A-7E)

## CLIMB SPEED SCHEDULE

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76E226(1)-02-72

Figure B10  
Military Power Climb Schedule





# TAKEOFF SPEED (A-7E)

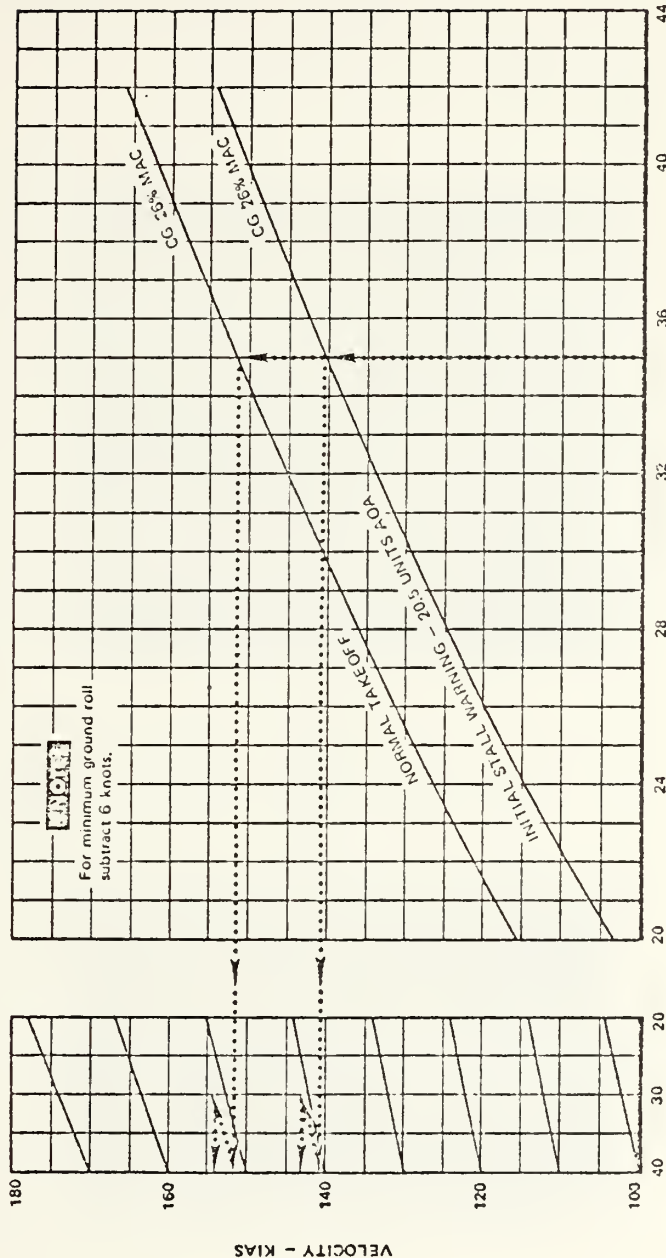
MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

CONDITIONS:  
MILITARY RATED THRUST  
LANDING CONFIGURATION  
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL

## NOTE

Data basis is 26% MAC. Increase speed 1/2 knot per 1% forward CG shift. Decrease speed 1/2 knot per 1% aft CG shift.



T.E. FLAPS - DEGREES

GROSS WEIGHT - 1,000 LB

76E254-02-72

Figure B11

Takeoff Speed



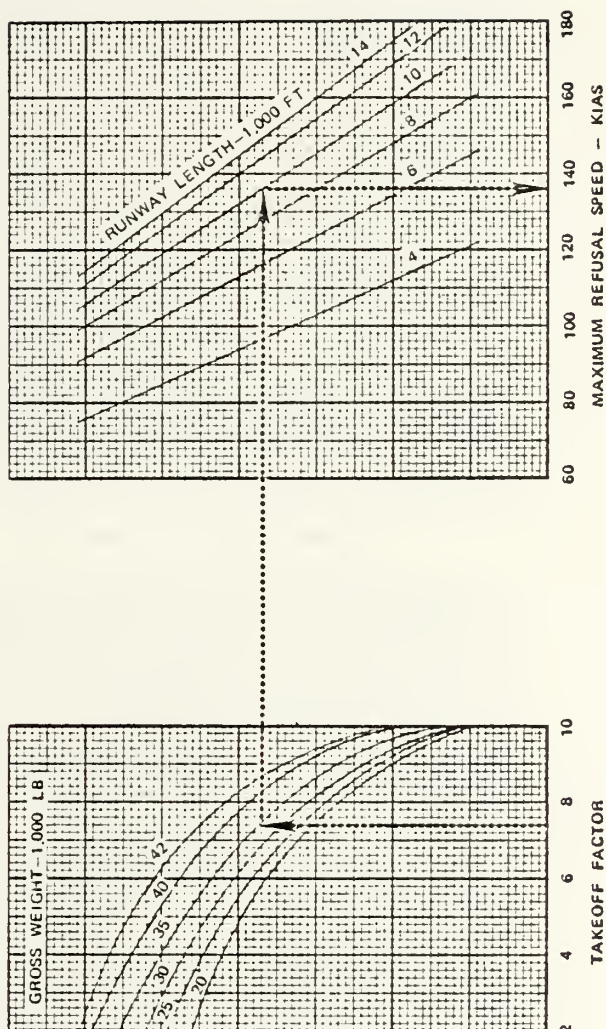
**MAXIMUM REFUSAL SPEED (A-7E).**

**WITH ANTI-SKID**

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

CONDITIONS:  
MILITARY RATED THRUST  
HARD SURFACE RUNWAY  
LANDING CONFIGURATION

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76E291-04-74

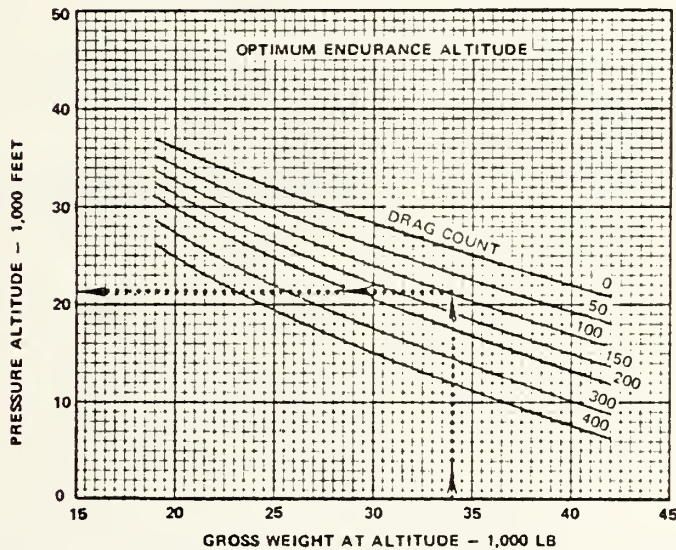
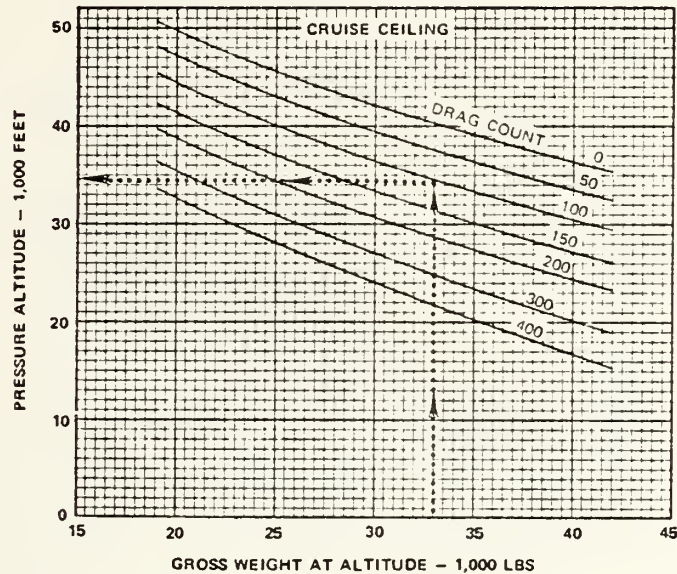
Figure B12  
Maximum Refusal Speed



# CRUISE CEILING AND OPTIMUM ENDURANCE ALTITUDE (A-7E)

MODEL: A-7E  
DATA BASIS: FLIGHT TEST  
DATE: NOVEMBER 1971

ENGINE: TF41-A-2  
FUEL GRADE: JP-5  
FUEL DENSITY: 6.8 LB/GAL



76E267-03-72

Figure B13

11-53

Cruise Ceiling and Optimum Endurance Altitude



## APPENDIX C

### Generated Algorithms

#### LOW LEVEL CRUISE PROGRAM

##### Phase I

$$M1 = -92.512 + 236.896G$$

##### Transfer Scale Versus Drag Count

$$A0 = -2.3287 - .26316D + .0073327D^2 - (7.513E-5)D^3 + (3.5396E-7)D^4 \\ - (7.78E-10)D^5 + (6.462E-13)D^6$$

$$A1 = 4.835 + 1.0956D - .030653D^2 + (3.1912E-4)D^3 - (1.5276E-6)D^4 \\ + (3.408E-9)D^5 - (2.8692E-12)D^6$$

$$A2 = 10.284 - 1.0719D + .031094D^2 - (3.2878E-4)D^3 + (1.595E-6)D^4 \\ - (3.6009E-9)D^5 + (3.0634E-12)D^6$$

$$S1 = A0 + (A1)(M1) + (A2)(M1)^2$$

##### Transfer Scale Versus Guidelines

$$B0 = 22.819 - 31.734I + 41.33I^2 - 5.0953I^3$$

$$B1 = -154.98 + 217.51I - 261.73I^2 + 35.905I^3$$

$$B2 = 405.08 - 525.56I + 607.49I^2 - 88.737I^3$$

$$B3 = -445.62 + 542.98I - 611.55I^2 + 92.894I^3$$

$$B4 = 184.78 - 204.42I + 225.89I^2 - 35.189I^3$$

$$S = B0 + (B1)(M1) + (B2)(M1)^2 + (B3)(M1)^3 + (B4)(M1)^4$$

##### Phase II

$$R = S + 2[(4.3732E-3) + .027743D]M^2$$





### Phase III

$$B0 = 5.6253 - 1.989R + 3.0252R^2 - 1.0761R^3 + .17675R^4 - .013095R^5 \\ + (3.526E-4)R^6$$

$$B1 = 205.3012 - 248.9317R + 91.66355R^2 - 15.55218R^3 + 1.224432R^4 \\ - .0395333R^5 + (2.896385E-4)R^6$$

$$B2 = -1052.123 + 1231.24R - 487.4233R^2 + 91.6522R^3 - 8.662962R^4 \\ + .3953974R^5 - .006905535R^6$$

$$B3 = 1680.142 - 1950.139R + 788.8513R^2 - 152.5733R^3 + 15.03819R^4 \\ - .7274139R^5 + .013707R^6$$

$$R3 = R$$

$$R1 = 2 \text{ (Integer (R/2))}$$

$$R2 = R1 + 2$$

$$N1 = B0 + (B1)(R1) + (B2)(R1)^2 + (B3)(R1)^3$$

$$N2 = B0 + (B1)(R2) + (B2)(R2)^2 + (B3)(R2)^3$$

### Using Linear Interpolation

$$N = N1 + [(N2-N1)(R3-R1)/2]$$

$$P = 4.9746N + (7.9043E-6)N^2$$

### Phase IV

$$N4 = [6.4375 + .010426T - (6.8925E-6)T^2 + (4.9127E-7)T^3]M$$

$$F = .1(N4)P$$

### TAKEOFF DISTANCE PROGRAM

$$B0 = 13.086 - .00017113A - (2.0655E-7)A^2 + (3.6861E-11)A^3 \\ - (2.4156E-15)A^4$$



$$B1 = -.045635 -(7.8931E-6)A + (3.7545E-9)A^2 -(9.7088E-13)A^3$$

$$+ (6.997E-17)A^4$$

$$B2 = -.001317 -(8.2558E-7)A + (4.0739E-10)A^2 -(8.548E-14)A^3$$

$$+ (5.4964E-18)A^4$$

$$B3 = -(1.9097E-5) + (1.3671E-8)A -(9.4694E-12)A^2 + (2.0434E-15)A^3$$

$$-(1.4617E-19)A^4$$

$$C = B0 + B1(B) + B2(B)^2 + B3(B)^3$$

If double datum on,

$$E = 1.9773 + .56598C$$

If double datum off,

$$E = .54178 + .65876C$$

$$G0 = -(4.8896E+5) + (8.4974E+1)G -(5.7856E-3)G^2 + (1.9373E-7)G^3$$

$$-(3.1744E-12)G^4 + (2.0446E-17)G^5$$

$$G1 = (5.8621E+4) -(1.0146E+1)G + (6.8807E-4)G^2 -(2.292E-8)G^3$$

$$+ (3.7387E-13)G^4 -(2.3964E-18)G^5$$

$$H = G0 + G1(E)$$

If relative humidity < 40%, K = H

If not, K = 4{[(I-40)/1000]+1}

$$L0 = 67.124 + .89509K + (2.3306E-5)K^2 -(1.6254E-9)K^3$$

$$+ (3.3728E-14)K^4$$

$$L1 = -9.0995 -(1.0856E-2)K + (2.1754E-7)K^2 -(2.5327E-11)K^3$$

$$+ (1.197E-15)K^4$$

$$L2 = (1.4782E-1) -(2.1666E-6)K + (3.4274E-9)K^2 -(2.7817E-13)K^3$$

$$+ (9.3077E-18)K^4$$

$$M = L0 + L1(L) + L2(L)^2$$

If winds calm, M = K



$$X0 = (4.5704E+1) + .93429M + (2.2265E-5)M^2 - (2.338E-9)M^3 \\ + (7.941E-14)M^4$$

$$X1 = 7.9472 + .014914M + (9.0708E-6)M^2 - (7.1235E-10)M^3 \\ + (3.0684E-14)M^4$$

$$X2 = 5.3616 - .0085136M + (3.5914E-6)M^2 - (4.5932E-10)M^3 \\ + (1.9889E-14)M^4$$

$$X = X0 + X1(N) + X2(N)^2$$

$$Q0 = 2604.2 - 2.1694X + .0010915X^2 - (1.1119E-7)X^3 + (3.662E-12)X^4$$

$$Q1 = -175.73 + .22601X - (7.5225E-5)X^2 + (7.7018E-9)X^3 \\ - (2.5437E-13)X^4$$

$$Q2 = 2.8549 - .0040102X + (1.2832E-6)X^2 - (1.3234E-10)X^3 \\ + (4.3908E-15)X^4$$

$$Q = Q0 + Q1(P) + Q2(P)^2$$

$$S0 = -400.79 + 1.5801Q - (2.0254E-4)Q^2 + (2.4111E-8)Q^3 \\ - (8.6737E-13)Q^4$$

$$S1 = 16.196 - .024333Q + (9.3484E-6)Q^2 - (1.2594E-9)Q^3 \\ + (4.7522E-14)Q^4$$

$$S2 = -.14758 + (2.359E-4)Q - (1.037E-7)Q^2 + (1.6016E-11)Q^3 \\ - (6.3195E-16)Q^4$$

$$S = S0 + S1(R) + S2(R)^2$$

MAXIMUM RANGE CRUISE TIME AND SPEED  
AT CONSTANT ALTITUDE PROGRAM

$$B0 = -1 + (5.0794E-3)H - (1.3968E-3)H^2 + (8.254E-5)H^3 \\ - (1.2698E-6)H^4$$



$$B1 = .05 + .0015159H + (1.123E-4)H^2 - (3.4921E-6)H^3 \\ + (7.9365E-8)H^4$$

$$N = B0 + B1(G)$$

$$B0 = .47803 + .0013417D + (6.2287E-6)D^2 - (1.6261E-8)D^3 \\ + (1.6438E-11)D^4$$

$$B1 = .08217 + (4.1209E-4)D - (4.5577E-6)D^2 + (1.6777E-8)D^3 \\ - (2.001E-11)D^4$$

$$B2 = (4.2143E-4) - (9.4397E-5)D + (1.2646E-6)D^2 - (4.8537E-9)D^3 \\ + (5.7222E-12)D^4$$

$$B3 = -(6.6767E-4) + (8.4671E-6)D - (1.0501E-7)D^2 + (3.6382E-10)D^3 \\ - (3.7828E-13)D^4$$

$$M = B0 + B1(N) + B2(N)^2 + B3(N)^3$$

$$M1 = M - [(60-T)(2)(M)/1200]$$

$$V = (710)(M1-.14) + 100 - E$$

$$T1 = D1/V$$

FUEL REQUIRED FOR MAXIMUM RANGE CRUISE  
AT CONSTANT ALTITUDE PROGRAM

$$B0 = 4.54 - .16444A + .0033932A^2 - (1.0283E-4)A^3 + (1.926E-6)A^4 \\ - (1.3757E-8)A^5$$

$$B1 = (3.22E-9) - (3.6664E-3)A + (8.9338E-4)A^2 - (5.5939E-5)A^3 \\ + (1.4593E-6)A^4 - (1.3281E-8)A^5$$

$$B2 = (6E-4) + (1.1203E-4)A - (2.3358E-5)A^2 + (1.4536E-6)A^3 \\ - (3.7144E-8)A^4 + (3.3334E-10)A^5$$

$$N = B0 + B1(G) + B2(G)^2$$





$$B0 = -(2.5399E-3)D + (9.7299E-5)D^2 - (2.3516E-7)D^3 \\ + (1.4251E-10)D^4$$

$$B1 = 2 + (4.2388E-3)D + (1.2326E-5)D^2 - (1.0298E-7)D^3 \\ + (1.7277E-10)D^4$$

$$L = B0 + B1(N)$$

$$F = L/V$$

$$R = (F)(T)/60$$

#### MAXIMUM RANGE CLIMB AIRSPEED SCHEDULE

$$S = 405.56 - .79075D + .0011382D^2 - (4.1018E-7)D^3$$

$$M = .86 - (2.1634E-3)D + (7.6582E-5)D^2 - (1.1344E-6)D^3 \\ + (7.2125E-9)D^4 - (2.3035E-11)D^5 + (3.6588E-14)D^6 \\ - (2.3062E-17)D^7$$

#### TAKEOFF AIRSPEED PROGRAM

$$U1 = 54.023 + (3.4787E-3)G - (1.9475E-8)G^2$$

$$U = U1 + [(26-P)/2]$$

$$V0 = -1917.1 + 61.604U - .70348U^2 + .0035661U^3 - (6.6578E-6)U^4$$

$$V1 = 76.824 - 2.4517U + .028779U^2 - (1.4753E-4)U^3 + (2.7872E-7)U^4$$

$$V2 = -.72239 + .023415U - (2.798E-4)U^2 + (1.4596E-6)U^3 \\ - (2.807E-9)U^4$$

$$V3 = V0 + V1(R) + V2(R)^2$$

#### MAXIMUM REFUSAL SPEED PROGRAM

$$B0 = -43.01 + 6.761G - .35159G^2 + .0080545G^3 - (6.7769E-5)G^4$$

$$B1 = 26.312 - 3.8382G + .20326G^2 - .047022G^3 + (3.994E-5)G^4$$



$$B2 = -4.9639 + .72723G - .038721G^2 + (8.985E-4)G^3 - (7.638E-6)G^4$$

$$B3 = .30288 - .044855G - .0023921G^2 - (5.5549E-5)G^3 \\ + (4.7217E-7)G^4$$

$$R = B0 + B1(E) + B2(E)^2 + B3(E)^3$$

$$B0 = -11.412 + 62.185L - 9.0037L^2 + .64921L^3 - .017455L^4$$

$$B1 = -.2811 - 4.2012L + .70377L^2 - .058693L^3 + .0017461L^4$$

$$M = B0 + B1(R)$$

#### OPTIMUM ENDURANCE ALTITUDE PROGRAM

$$B0 = 55.333 + .073076D - (9.7836E-4)D^2 + (3.5015E-6)D^3 \\ - (3.9782E-9)D^4$$

$$B1 = -1.1 - (8.0597E-3)D + (8.0097E-5)D^2 - (2.8836E-7)D^3 \\ + (3.3032E-10)D^4$$

$$B2 = (6.6667E-3) + (1.2541E-4)D - (1.4039E-6)D^2$$

$$H = B0 + B1(G) + B2(G)^2$$

#### CRUISE CEILING PROGRAM

$$B0 = 85.118 - .29117D + .0030434D^2 - (1.2851E-5)D^3 + (1.6621E-8)D^4$$

$$B1 = -2.7877 + .025635D - (3.3063E-4)D^2 + (1.4162E-6)D^3 \\ - (1.8343E-9)D^4$$

$$B2 = .063327 - (8.5289E-4)D + (1.0814E-5)D^2 - (4.6514E-8)D^3 \\ + (6.0606E-11)D^4$$

$$B3 = -(6.0468E-4) + (9.0826E-6)D - (1.143E-7)D^2 + (4.9304E-10)D^3 \\ - (6.4567E-13)D^4$$

$$H = B0 + (B1)G + (B2)G^2 + (B3)G^3$$



# APPENDIX D

## HP-9830 Programs and Lists of Variables

```

1 REM THIS PROGRAM CALCULATES THE FUEL FLOW AND LBFUEL/NAUTICAL MILE FOR AN
2 REM A-7E FLYING A LOW LEVEL MISSION AND IS DEPENDENT ON 4 VARIABLES --
3 REM GROSS WEIGHT, DRAG COUNT, MACH NUMBER, AND TEMPERATURE (CENTIGRADE)
10 PRINT "ENTER GROSS WT, DRAG CT, MACH #, AND TEMP (CENT)"
11 PRINT
12 PRINT
20 INPUT G,D,M,T
40 G=G/1000
50 M1=0.38813+0.0042981*G
54 GOSUB 800
56 I=0
58 GOSUB 600
60 S2=S
70 IF S1>S2 THEN 100
90 S=S2
95 GOTO 300
100 I=1
110 GOSUB 600
120 S3=S
130 IF S1<S3 THEN 200
140 S2=S3
150 I=I+1
160 GOSUB 600
170 GOTO 120
200 I1=(S1-S2)/(S3-S2)
210 M1=M
220 I=I-1+I1
221 I=INT(I)
222 GOSUB 600
223 S2=S
224 I=I+1
225 GOSUB 600
226 S3=S
227 S=S2+(I1*(S3-S2))
240 GOTO 300
285 PRINT
286 PRINT
300 R=S+2*(4.3732E-03+0.027743*D)+M+2
301 R3=R
302 R1=2*INT(R/2)
304 R2=R1+2
306 J=1
308 IF J=2 THEN 311
309 R=R1
310 GOTO 319
311 R=R2
319 B0=5.6253-1.989*R+3.0252*R+3-1.0761*R+3+0.17675*R+4
320 B0=B0-0.013095*R+5+3.528E-04*R+6
330 B1=205.3012-248.9317*R+91.66355*R+3-15.55218*R+3+1.224+32*R+4
340 B1=B1-0.0395333*R+5+2.896385E-04*R+6
350 B2=-1052.123+1231.24*R-487.4233*R+2+91.6522*R+3-8.662962*R+4+0.3953974*R+5
360 B2=B2-0.006905535*R+6
370 B3=1680.142-1950.139*R+788.8513*R+2-152.5733*R+3+15.05819*R+4
380 B3=B3-0.7274139*R+5+0.013707*R+6
390 B4=-864.6875+1000.443*R-408.7451*R+2+80.08314*R+3-8.02958*R+4
400 B4=B4+0.3982527*R+5-7.720617E-03*R+6
430 N=B0+B1*M+B2*M+2+B3*M+3+B4*M+4
440 IF J=2 THEN 480
450 N1=N

```



```

455 J=2
460 GOTO 311
475 R=2
480 N2=N
490 N=N1+(N2-N1)*(R3-R1)/2
500 REM      COMPLETED CALCULATION OF INTERMEDIATE # BY LINEAR INTERPOLATION
510 P=4.9746*N+7.9043E-06*N^2
520 H4=(6.4375+0.010426*T-6.8935E-06*T^2+4.9127E-07*T^3)*M
530 F=(0.1+N4*P)+1000
539 F=INT(F)
540 PRINT "GROSS WT="G+1000
541 PRINT "TS="S"DC="D"M="M
542 PRINT "TEMP="T
543 PRINT "REF #="R3
544 PRINT "N="N
545 PRINT "LBFUEL NM="P
550 PRINT "FUEL FLOW=" F
551 PRINT
555 GOTO 10
600 B0=22.819-31.734*I+41.33*I^2-5.0953*I^3
610 B1=-154.98+217.51*I-261.73*I^2+35.905*I^3
620 B2=405.08-525.56*I+607.49*I^2-88.737*I^3
630 B3=-445.62+542.98*I-611.55*I^2+92.894*I^3
640 B4=184.78-204.42*I+225.89*I^2-35.189*I^3
650 S=B0+B1*M1+B2*M1^2+B3*M1^3+B4*M1^4
660 RETURN
800 A0=-2.3287-0.26316*D+0.0073327*D^2-7.513E-05*D^3+3.5396E-07*D^4
810 A0=A0-7.78E-10*D^5+6.4624E-13*D^6
820 A1=4.835+1.0956*D-0.030653*D^2+3.1913E-04*D^3-1.5276E-06*D^4
830 A1=A1+3.408E-09*D^5-2.8692E-12*D^6
840 A2=10.284-1.0719*D+0.031094*D^2-3.2878E-04*D^3+1.595E-06*D^4
850 A2=A2-3.6009E-09*D^5+3.0634E-12*D^6
860 S1=A0+A1*M1+A2*M1^2
870 RETURN
880 END

```





## List of Variables for Program 1

<u>Variable</u>	<u>Definition</u>
G	Gross weight (lbs.)
D	Drag count
T	Temperature (°C)
M	Mach number
M1	Result of lower graph, Figure B1
I	Guidelines, numbered top to bottom consecutively
S	Transfer Scale calculated as function of I
S1	Transfer Scale calculated as function of D
S2	Transfer Scale calculated for upper guideline
S3	Transfer Scale calculated for lower guideline
I1	Relative Transfer Scale location between guidelines
R,R3	Reference number
R1	Even reference number below actual reference number
R2	Even reference number above actual reference number
J	Integer counter
N	Result of lower graph, Figure B3
N1	Result of lower graph, Figure B3 for R1
N2	Result of lower graph, Figure B3 for R2
N4	Result of lower graph, Figure B4
A0,B0, A1,B1	Coefficients
A2,B2, B3,B4	Coefficients
P	Pounds of fuel per nautical mile
F	Fuel flow



## Program 2

```

1 REM THIS PROGRAM CALCULATES THE TAKEOFF DISTANCE REQUIRED FOR AN A-7E
2 REM IT IS DEPENDENT ON 9 VARIABLES --
3 REM GROSS WEIGHT,PNWY ALTITUDE,TEMP,DRAG COUNT,RELATIVE HUMIDITY,WINDS
4 REM PNWY SLOPE,CENTER OF GRAVITY LOCATION,FLAPS, AND DOUBLE DATUM STATUS
5 PRINT "INPUT ALT,TEMP,DC,GN"
10 INPUT A,B,D,G
11 I=50
12 L=10
13 N=1
14 P=27
20 R=25
100 B0=13.086-0.00017113*A-2.0655E-07*A+2+3.6861E-11*A+3
101 B0=B0-2.4156E-15*A+4
110 B1=-0.045635-7.8931E-06*A+3.7545E-09*A+2
111 B1=B1-9.7088E-13*A+3+6.997E-17*A+4
120 B2=-0.001317-8.2558E-07*A+4.0739E-10*A+2
121 B2=B2-8.548E-14*A+3+5.4964E-18*A+4
130 B3=-1.9097E-05+1.3671E-08*A-9.4694E-12*A+2+2.0434E-15*A+3
140 B3=B3-1.4617E-19*A+4
150 C=B0+B1+B*B2+B+2+B3+B+3
160 IF D=1 THEN 190
170 E=0.54178+0.65876*C
180 GOTO 200
190 E=1.9773+0.56598*C
200 G0=-4.8896E+05+8.4974E+01*G-5.7856E-03*G+2+1.9373E-07*G+3-3.1744E-12*G+4
210 G0=G0+2.0446E-17*G+5
220 G1=5.8621E+04-1.0146E+01*G+6.8807E-04*G+2-2.292E-08*G+3+3.7387E-13*G+4
230 G1=G1-2.3964E-18*G+5
340 H=G0+G1+E
350 J=0
360 IF I<40 THEN 380
370 J=(I-40)/1000
380 K=H*J+H
385 IF L=0 THEN 340
390 L0=6.7124E+01+8.9509E-01*K+2.3306E-05*K+2-1.6254E-09*K+3+3.3728E-14*K+4
390 L1=-9.0995-1.0856E-02*K+2.1754E-07*K+2-2.5327E-11*K+3+1.197E-15*K+4
310 L2=1.4782E-01-2.1666E-06*K+3.4274E-09*K+2-2.7817E-13*K+3+9.3077E-18*K+4
320 M=L0+L1+L+L2+L+2
330 GOTO 350
340 M=K
350 X0=4.5704E+01+9.3429E-01*M+2.3265E-05*M+2-2.338E-09*M+3+7.941E-14*M+4
360 X1=7.9472+1.4914E-02*M+9.0708E-06*M+2-7.1235E-10*M+3+3.0684E-14*M+4
370 X2=5.3616-8.5136E-03*M+3.5914E-06*M+2-4.5932E-10*M+3+1.9889E-14*M+4
380 X=X0+X1+M+X2+M+2
390 Q0=3.6042E+03-2.1694*X+1.0915E-03*X+2-1.1119E-07*X+3+3.662E-12*X+4
400 Q1=-1.7573E+02+2.2601E-01*X-7.5235E-05*X+2+7.7018E-09*X+3-2.5437E-13*X+4
410 Q2=2.8549-4.0102E-03*X+1.2832E-06*X+2-1.3234E-10*X+3+4.3908E-15*X+4
420 Q=Q0+Q1+P+Q2+P+2
430 S0=-4.0079E+02+1.5801*Q-2.0254E-04*Q+2+2.4111E-08*Q+3-8.6737E-13*Q+4
440 S1=1.6196E+01-2.4338E-02*Q+9.3484E-06*Q+2-1.2594E-09*Q+3+4.7522E-14*Q+4
450 S2=-1.4758E-01+2.359E-04*Q-1.037E-07*Q+2+1.6016E-11*Q+3-6.3195E-16*Q+4
460 S=S0+S1+R+S2+R+2
470 S=INT(S)
479 PRINT "          FOR"
480 PRINT "GN="G" ALT="A" TEMP="B" DC="D"PH="I"HDWD="L
482 PRINT "RNWY SLP="N"% CEN GRAV="P"FLAPS="R
483 PRINT
530 PRINT "TAKEOFF ROLL DIST="S
531 GOTO 9
532 END

```



## List of Variables for Program 2

<u>Variable</u>	<u>Definition</u>
A	Runway Altitude (feet)
B	Temperature (°C)
D	Double datum status (1 indicates "with")
G	Gross weight (lbs.)
I	Relative humidity (%)
L	Headwind (kts.)
N	Runway slope (%)
P	Center of gravity (%)
R	Flap position (degrees)
C	Result of upper graph, Figure B5
E	Takeoff factor
H	Unadjusted ground roll distance, Figure B6
J	Adjustment factor due to relative humidity
K	Ground roll distance (GRD) adjusted for relative humidity
M	GRD adjusted for wind
X	GRD adjusted for runway slope
Q	GRD adjusted for the center of gravity location
S	True GRD (also adjusted for flap position)
B0,G0,L0, X0,Q0	Coefficients
B1,G1,L1, X1,Q1	Coefficients
B2,G2,L2, X2,Q2	Coefficients
B3,S0, S1,S2	Coefficients



# Program 3

```

1 REM THIS PROGRAM CALCULATES THE A-7E MAXIMUM RANGE, AIRSPEED AND
2 REM TIME OF FLIGHT AND IS DEPENDENT ON 6 VARIABLES --
3 REM GROSS WEIGHT, ALTITUDE, DRAG COEFF, TEMPERATURE, WINDS, AND DISTANCE
9 PRINT "INPUT GW,ALT,DC,TEMP(*C),HDWD,DISTANCE"
10 INPUT G,H,D,T,L,D1
30 G=G/1000
40 H=H/1000
50 A0=-1+5.0794E-03*H-1.3968E-03*H^2-3.4912E-06*H^3+7.9365E-08*H^4
60 A1=0.05+0.0015159*H+1.123E-04*H^2-3.4921E-06*H^3+7.9365E-08*H^4
70 N=A0+A1*G
80 B0=0.47803-0.0013417*D+6.2287E-06*D^2-1.6261E-08*D^3+1.6438E-11*D^4
85 B1=0.08217+4.1209E-04*D-4.5577E-06*D^2+1.6777E-08*D^3-2.001E-11*D^4
90 B2=4.2143E-04-9.4397E-05*D+1.2646E-06*D^2-4.8537E-09*D^3+5.7223E-12*D^4
95 B3=-6.6767E-04+8.4671E-06*D-1.0501E-07*D^2+3.6382E-10*D^3-3.7828E-13*D^4
100 M=B0+B1*N+B2*H^2+B3*H^3
110 M=M-((60-T)*2*M)/(10+120)
120 V=710*(M-0.14)+100-L
130 T1=D1/V
135 V=INT(V)
140 PRINT
150 PRINT "FOR"
160 PRINT "GW="G" ALT="H" DC="D"TEMP="T" HDWD="L"DIST="D1
161 PRINT
162 PRINT "GROUND SPEED="V" TIME OF FLIGHT="T1
170 END

```





List of Variables for Program 3

<u>Variable</u>	<u>Definition</u>
G	Gross weight (lbs.)
H	Altitude (ft.)
D	Drag count
T	Temperature (°C)
L	Headwind (kts.)
D1	Distance to fly
N	Result of first chart, Figure B8
M	Cruise Mach number (adjusted and unadjusted for T)
V	Ground speed (kts.)
T1	Time of flight
A0,B0	Coefficients
A1,B1	Coefficients
B3	Coefficient



# Program 4

```

10 REM      THIS PROGRAM CALCULATES FUEL REQUIRED FOR MAX RANGE AT CONSTANT
11 REM  ALTITUDE FOR AN A-7E AND IS DEPENDENT ON 5 VARIABLES --
12 REM  GROSS WEIGHT, ALTITUDE, DRAG COUNT, TRUE AIRSPEED, AND TIME (MINUTES)
20 PRINT "ENTER GROSS WT, ALT, DRAG CT, TAS, TIME (MINUTES)"
21 PRINT
22 PRINT
30 INPUT G,A,D,V,T
35 PRINT "GROSS WT="G
36 PRINT "ALTITUDE="A
37 PRINT "DRAG COUNT="D
38 PRINT "TRUE AIRSPEED="V
39 PRINT "TIME OF FLIGHT="T
40 G=G/1000
50 A=A/1000
60 B0=4.54-0.16444*A+0.0033932*A^2-1.0283E-04*A^3+1.926E-06*A^4-1.3757E-08*A^5
70 B1=-3.6664E-03*A+8.9338E-04*A^2-5.5939E-05*A^3+1.4593E-06*A^4-1.3291E-08*A^5
80 B2=6E-04+1.1203E-04*A-2.3358E-05*A^2+1.4536E-06*A^3-3.7144E-08*A^4
85 B3=B3+3.3334E-10*A^5
90 N=B0+B1*G+B2*G^2
100 A0=-3.5399E-03*D+9.7299E-05*D^2-2.3516E-07*D^3+1.4251E-10*D^4
110 A1=2+4.2388E-03*D+1.2326E-05*D^2-1.0298E-07*D^3+1.7277E-10*D^4
120 L=A0+A1*N
130 F=L*V
140 R=F*T.60
141 L=(INT(L+1000))/1000
142 F=(INT(F)
143 R=(INT(R)
147 PRINT
148 PRINT
150 PRINT "LB FUEL NM="L" FUEL FLOW="F
155 PRINT "FUEL REQUIRED="R
156 PRINT
157 PRINT
160 GOTO 20
170 END

```



List of Variables for Program 4

<u>Variable</u>	<u>Definition</u>
G	Gross weight (lbs.)
A	Altitude (ft.)
D	Drag count
V	True airspeed (kts.)
T	Time of flight (minutes)
N	Result of first chart, Figure B9
L	Pounds of fuel per nautical mile
F	Fuel flow
R	Fuel required
B0,A0	Coefficients
B1,A1	Coefficients
B2	Coefficient



# Program 5

```

1 REM THIS PROGRAM CALCULATES THE CLIMB AIRSPEED OF AN A-7E
2 REM (INDICATED AIRSPEED BELOW 20,000')
3 REM (MACH NUMBER ABOVE 20,000')
10 D=0
12 PRINT "CLIMB AIRSPEED SCHEDULE"
15 PRINT "DRAG CT      CLIMB AIRSPEED      CLIMB MACH"
16 PRINT "              (IAS TO 20000') (ABOVE 20000') "
20 S=400.56-0.79075*D+0.0011382*D^2-4.1018E-07*D^3
21 S=INT(S)
30 M=0.86-2.1634E-03*D+7.6583E-05*D^2-1.1344E-06*D^3+7.2125E-09*D^4-2.3035E-11*D
40 M=M+3.6588E-14*D^5-2.3062E-17*D^7
42 M=M*1000
44 M=INT(M)
46 M=M/1000
55 PRINT D,S,M
60 D=D+30
70 IF D<310 THEN 20
80 END

```

↑ 5





List of Variables for Program 5

<u>Variable</u>	<u>Definition</u>
D	Drag count
M	Mach number
S	Calibrated airspeed (kts.)



# Program 6

```

400 REM THIS PROGRAM CALCULATES THE TAKEOFF AIRSPEED OF AN A-7E
401 REM UNDER VARYING GROSS WEIGHTS, FLAP POSITIONS,
402 REM AND CENTER OF GRAVITY LOCATIONS
498 R=20
499 P=20
500 G=20000
501 PRINT "FOR GROSS WEIGHT="G
502 PRINT
503 PRINT
504 PRINT "FLAPS          CG          TAKEOFF AIRSPEED"
530 U1=5.4023E+01+3.4787E-03*G-1.9475E-08*G^2
540 U=U1+(26-P)/2
550 V0=-1.9171E+03+6.1604E+01*U-7.0348E-01*U^2+3.5661E-03*U^3-6.6578E-06*U^4
560 V1=7.6824E+01-2.4517*U+2.8779E-02*U^2-1.4753E-04*U^3+2.7873E-07*U^4
570 V2=-7.2239E-01+2.3415E-02*U-2.798E-04*U^2+1.4596E-06*U^3-2.807E-09*U^4
580 V3=V0+V1+R+V2*R^2
590 V4=INT(V3)
600 PRINT R,P,V4
610 R=R+5
620 IF R>40 THEN 630
625 GOTO 530
630 P=P+3
631 R=20
635 IF P>35 THEN 650
640 GOTO 530
650 G=G+3000
651 R=20
652 P=20
655 PRINT
656 PRINT
657 PRINT
660 PRINT "FOR GROSS WEIGHT="G
662 PRINT
663 PRINT
669 IF G>42000 THEN 710
670 GOTO 530
710 END

```



List of Variables for Program 6

<u>Variable</u>	<u>Definition</u>
R	Flap position (degrees)
P	Center of gravity (%)
G	Gross weight (lbs.)
U1	Unadjusted takeoff airspeed
U	Takeoff airspeed adjusted for center of gravity
V4	Actual takeoff airspeed (adjusted for flap position)
V0,V1, V2,V3	Coefficients



# Program 7

```

1 REM THIS PROGRAM CALCULATES THE MAXIMUM REFUSAL SPEED
2 REM FOR AN A-7E USING ANTI-SKID
3 REM IT IS DEPENDENT ON 5 VARIABLES --
4 REM GROSS WEIGHT, TEMP, RNMW LENGTH, RNMW ALTITUDE, AND DOUBLE DATUM STATUS
9 PRINT "INPUT ALT,TEMP,RNMW LTH,GW,DOUBLE DATUM"
10 INPUT A,B,L,G,D
15 G=G/1000
20 L=L/1000
70 PRINT "ALTITUDE="A
71 PRINT "TEMP="B
72 PRINT "RNMW LTH="L*1000
73 PRINT "GROSS WT="G*1000
75 PRINT "DD="D
100 B0=13.086-0.00017113*A-2.0655E-07*A^2+3.6861E-11*A^3
101 B0=B0-2.4156E-15*A^4
110 B1=-0.045635-7.8931E-06*A+3.7545E-09*A^2
111 B1=B1-9.7088E-13*A^3+6.997E-17*A^4
120 B2=-0.001317-8.2558E-07*A+4.0739E-10*A^2
121 B2=B2-8.548E-14*A^3+5.4964E-19*A^4
130 B3=-1.9097E-05+1.3671E-08*A-9.4694E-12*A^2+2.0434E-15*A^3
140 B3=B3-1.4617E-19*A^4
150 C=B0+B1*B+B2*B^2+B3*B^3
160 IF D=1 THEN 190
170 E=0.54178+0.65876*C
180 GOTO 200
190 E=1.9773+0.56598*C
200 B0=-43.01+6.761*G-0.35159*G^2+0.0080545*G^3-6.7769E-05*G^4
210 B1=26.312-3.8382*G+0.20326*G^2-0.0047022*G^3+3.994E-05*G^4
220 B2=-4.9639+0.72723*G-0.038721*G^2+8.985E-04*G^3-7.638E-06*G^4
230 B3=0.30288-0.044855*G+0.0023921*G^2-5.5549E-05*G^3+4.7217E-07*G^4
240 R=B0+B1*E+B2*E^2+B3*E^3
250 B0=-11.412+62.185*L-9.0037*L^2+0.64921*L^3-0.017455*L^4
260 B1=-0.2811-4.2012*L+0.70377*L^2-0.058693*L^3+0.0017461*L^4
270 M=B0+B1*R
271 M=INT(M)
272 PRINT
275 PRINT " TAKEOFF FACTOR ="E
276 PRINT
280 PRINT "MAX REFUSAL SPEED = ",M
281 PRINT
290 GOTO 9
300 END

```





List of Variables for Program 7

<u>Variable</u>	<u>Definition</u>
A	Runway Altitude (ft.)
B	Temperature (°C)
L	Runway length (ft.)
G	Gross weight (lbs.)
D	Double datum status (1 indicates "with")
C	Result of upper chart, Figure B5
E	Takeoff factor
R	Result of first chart, Figure B12
M	Maximum refusal speed (kts.)
B0,B1, B2,B3	Coefficients



# Program 8

```

1 REM THIS PROGRAM CALCULATES THE OPTIMUM ENDURANCE ALTITUDE
2 REM OF AN A-7E AT VARYING GROSS WEIGHTS AND DRAG COUNTS
4 DIM B(3)
5 G=19
6 D=0
10 PRINT "OPTIMUM ENDURANCE ALT "
20 PRINT "GROSS WT    DRAG CT    OPT END ALT"
50 G=G+3
90 B(3)=55.333+0.073076*D-9.7836E-04*D^2+3.5015E-06*D^3-3.9782E-09*D^4
90 B(1)=-1.1-8.0597E-03*D+8.0097E-05*D^2-2.8836E-07*D^3+3.3032E-10*D^4
100 B(2)=6.6667E-03+1.3541E-04*D-1.4039E-06*D^2+5.2032E-09*D^3-6.0218E-12*D^4
110 H=B(3)+B(1)+G*B(2)+G^2
115 Z=INT(H*1000)
118 X=G*1000
119 PRINT X,D,Z
120 D=D+30
121 IF D<310 THEN 80
122 D=0
123 IF G<45 THEN 50
140 END

```



List of Variables for Program 8

<u>Variable</u>	<u>Definition</u>
G	Gross weight (lbs. times 1000)
D	Drag count
H	Optimum endurance altitude (ft.)
Z	Optimum endurance altitude (integer format)
X	Gross weight (lbs.)
B1,B2,B3	Coefficients



# Program 9

```

1 REM THIS PROGRAM CALCULATES THE CRUISE CEILING OF AN A-7E
2 REM UNDER VARYING GROSS WEIGHTS AND DRAG COUNTS
4 DIM B(4)
5 G=19
6 D=0
10 PRINT "CRUISE CEILING"
20 PRINT "GROSS WT    DRAG CT          CRUISE CEILING"
50 G=G+3
80 B(4)=85.118-0.29117*D+0.0030434*D^2-1.2851E-05*D^3+1.6621E-08*D^4
90 B(1)=-2.7877+0.025635*D-3.3063E-04*D^2+1.4162E-06*D^3-1.8343E-09*D^4
100 B(2)=0.063327-8.5288E-04*D+1.0814E-05*D^2-4.6514E-08*D^3+6.0606E-11*D^4
105 B(3)=-8.0468E-04+9.0826E-06*D-1.143E-07*D^2+4.9304E-10*D^3-6.4567E-13*D^4
110 H=B(4)+B(1)+G*B(2)+B(3)*G^3
115 Z=INT(H+1000)
118 X=G+1000
119 PRINT X,D,Z
120 D=D+30
121 IF D<310 THEN 80
122 D=0
123 IF G<45 THEN 50
140 END

```





List of Variables for Program 9

<u>Variable</u>	<u>Definition</u>
G	Gross weight (lbs. times 1000)
D	Drag count
H	Cruise ceiling (ft.)
Z	Cruise ceiling (integer format)
X	Gross weight (lbs.)
B1,B2, B3,B4	Coefficients



## APPENDIX E

### TI-59 Programs and User Information

#### USER INFORMATION FOR PROGRAM 1

Program: Low Level Cruise Performance

Number of Steps: 1386

Computation Time: 90-110 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	drag count	C	drag count
3	mach number	D	mach number
4	temperature (°C)	E	Transfer Scale
5	.---	R/S	Unusable number
6	read in cards 3 & 4	-	---
7	drag count	C	Transfer Scale
8	mach number	D	mach number
9	temperature (°C)	E	lb.fuel/nautical mile
0	---	R/S	fuel flow



```

000 76 LBL
001 11 R
002 55 +
003 01 1
004 00 0
005 00 0
006 00 0
007 95 =
008 42 STD
009 00 00
010 91 R/S
011 76 LBL
012 12 8
013 55 +
014 01 1
015 00 0
016 00 0
017 00 0
018 95 =
019 42 STD
020 01 01
021 91 R/S
022 76 LBL
023 13 0
024 42 STD
025 02 02
026 91 R/S
027 76 LBL
028 14 0
029 42 STD
030 03 03
031 91 R/S
032 76 LBL
033 15 E
034 42 STD
035 04 04
036 53 (
037 93 .
038 03 3
039 08 8
040 08 8
041 01 1
042 03 3
043 85 +
044 93 .
045 00 0
046 00 0
047 04 4
048 02 2
049 09 9

```

```

050 08 8
051 01 1
052 85 X
053 43 RCL
054 00 00
055 95 =
056 42 STD
057 05 05
058 25 CLR
059 75 -
060 53 (
061 02 2
062 93 .
063 03 3
064 02 2
065 08 8
066 07 7
067 85 +
068 93 .
069 02 2
070 06 6
071 03 3
072 01 1
073 06 6
074 85 X
075 43 RCL
076 02 02
077 75 -
078 93 .
079 00 0
080 00 0
081 07 7
082 03 3
083 03 3
084 02 2
085 07 7
086 65 X
087 43 RCL
088 02 02
089 33 X²
090 85 +
091 07 7
092 93 .
093 05 5
094 01 1
095 03 3
096 52 EE
097 94 +/-
098 05 5
099 65 X

```

```

100 43 RCL
101 02 02
102 45 YX
103 03 3
104 75 -
105 03 3
106 93 .
107 05 5
108 03 3
109 09 9
110 06 6
111 52 EE
112 94 +/-
113 07 7
114 65 X
115 43 RCL
116 02 02
117 45 YX
118 04 4
119 85 +
120 07 7
121 93 .
122 07 7
123 08 8
124 52 EE
125 94 +/-
126 01 1
127 00 0
128 65 X
129 43 RCL
130 02 02
131 45 YX
132 05 5
133 75 -
134 06 6
135 93 .
136 04 4
137 06 6
138 02 2
139 04 4
140 52 EE
141 94 +/-
142 01 1
143 03 3
144 65 X
145 43 RCL
146 02 02
147 45 YX
148 06 6
149 54 )

```



150 85 +  
 151 53 (   
 152 04 4  
 153 93 .  
 154 08 8  
 155 03 3  
 156 05 5  
 157 85 +  
 158 01 1  
 159 93 .  
 160 00 0  
 161 09 9  
 162 05 5  
 163 06 6  
 164 65 x  
 165 43 RCL  
 166 02 02  
 167 75 -  
 168 93 .  
 169 00 0  
 170 03 3  
 171 00 0  
 172 06 6  
 173 05 5  
 174 03 3  
 175 65 x  
 176 43 RCL  
 177 02 02  
 178 33 X²  
 179 85 +  
 180 03 3  
 181 93 .  
 182 01 1  
 183 09 9  
 184 01 1  
 185 02 2  
 186 52 EE  
 187 94 +/-  
 188 04 4  
 189 65 x  
 190 43 RCL  
 191 02 02  
 192 45 YX  
 193 03 3  
 194 75 -  
 195 01 1  
 196 93 .  
 197 05 5  
 198 02 2  
 199 07 7

200 06 6  
 201 52 EE  
 202 94 +/-  
 203 06 6  
 204 65 x  
 205 43 RCL  
 206 02 02  
 207 45 YX  
 208 04 4  
 209 85 +  
 210 03 3  
 211 93 .  
 212 04 4  
 213 00 0  
 214 08 8  
 215 52 EE  
 216 94 +/-  
 217 09 9  
 218 65 x  
 219 43 RCL  
 220 02 02  
 221 45 YX  
 222 05 5  
 223 75 -  
 224 02 2  
 225 93 .  
 226 08 8  
 227 06 6  
 228 09 9  
 229 02 2  
 230 52 EE  
 231 94 +/-  
 232 01 1  
 233 02 2  
 234 65 x  
 235 43 RCL  
 236 02 02  
 237 45 YX  
 238 06 6  
 239 54 )  
 240 65 x  
 241 43 RCL  
 242 05 05  
 243 85 +  
 244 53 (   
 245 01 1  
 246 00 0  
 247 93 .  
 248 02 2  
 249 08 8

250 04 4  
 251 75 -  
 252 01 1  
 253 93 .  
 254 00 0  
 255 07 7  
 256 01 1  
 257 09 9  
 258 65 x  
 259 43 RCL  
 260 02 02  
 261 85 +  
 262 93 .  
 263 00 0  
 264 03 3  
 265 01 1  
 266 00 0  
 267 09 9  
 268 04 4  
 269 65 x  
 270 43 RCL  
 271 02 02  
 272 33 X²  
 273 75 -  
 274 03 3  
 275 93 .  
 276 02 2  
 277 08 8  
 278 07 7  
 279 08 8  
 280 52 EE  
 281 94 +/-  
 282 04 4  
 283 65 x  
 284 43 RCL  
 285 02 02  
 286 45 YX  
 287 03 3  
 288 85 +  
 289 01 1  
 290 93 .  
 291 05 5  
 292 09 9  
 293 05 5  
 294 52 EE  
 295 94 +/-  
 296 06 6  
 297 65 x  
 298 43 RCL  
 299 02 02





300 45 YX  
 301 04 4  
 302 75 -  
 303 03 3  
 304 93 .  
 305 06 6  
 306 00 0  
 307 00 0  
 308 09 9  
 309 52 EE  
 310 94 +/-  
 311 09 9  
 312 65 X  
 313 43 RCL  
 314 02 02  
 315 45 YX  
 316 05 5  
 317 85 +  
 318 03 3  
 319 93 .  
 320 00 0  
 321 06 6  
 322 03 3  
 323 04 4  
 324 52 EE  
 325 94 +/-  
 326 01 1  
 327 02 2  
 328 65 X  
 329 43 RCL  
 330 02 02  
 331 45 YX  
 332 06 6  
 333 54 )  
 334 65 X  
 335 43 RCL  
 336 05 05  
 337 33 X<sup>2</sup>  
 338 95 =  
 339 42 STD  
 340 06 06  
 341 25 CLR  
 342 42 STD  
 343 07 07  
 344 71 SBR  
 345 04 04  
 346 43 43  
 347 42 STD  
 348 08 08  
 349 32 X:T

350 43 RCL  
 351 06 06  
 352 22 INV  
 353 77 GE  
 354 03 03  
 355 88 88  
 356 01 1  
 357 42 STD  
 358 07 07  
 359 71 SBR  
 360 04 04  
 361 43 43  
 362 42 STD  
 363 09 09  
 364 32 X:T  
 365 43 RCL  
 366 06 06  
 367 22 INV  
 368 77 GE  
 369 04 04  
 370 01 01  
 371 43 RCL  
 372 09 09  
 373 42 STD  
 374 08 08  
 375 43 RCL  
 376 07 07  
 377 85 +  
 378 01 1  
 379 95 =  
 380 42 STD  
 381 07 07  
 382 71 SBR  
 383 04 04  
 384 43 43  
 385 61 GTD  
 386 03 03  
 387 62 62  
 388 43 RCL  
 389 03 03  
 390 42 STD  
 391 05 05  
 392 71 SBR  
 393 04 04  
 394 43 43  
 395 42 STD  
 396 05 05  
 397 61 GTD  
 398 06 06  
 399 68 68

400 00 0  
 401 53 (   
 402 43 RCL  
 403 06 06  
 404 75 -  
 405 43 RCL  
 406 08 08  
 407 54 )  
 408 55 +  
 409 53 (   
 410 43 RCL  
 411 09 09  
 412 75 -  
 413 43 RCL  
 414 08 08  
 415 54 )  
 416 95 =  
 417 42 STD  
 418 00 00  
 419 43 RCL  
 420 03 03  
 421 42 STD  
 422 05 05  
 423 43 RCL  
 424 07 07  
 425 75 -  
 426 01 1  
 427 85 +  
 428 43 RCL  
 429 00 00  
 430 95 =  
 431 42 STD  
 432 07 07  
 433 71 SBR  
 434 04 04  
 435 43 43  
 436 42 STD  
 437 05 05  
 438 61 GTD  
 439 06 06  
 440 68 68  
 441 00 0  
 442 00 0  
 443 02 2  
 444 02 2  
 445 93 .  
 446 08 8  
 447 01 1  
 448 09 9  
 449 75 -



450 03 3  
 451 01 1  
 452 93 .  
 453 07 7  
 454 03 3  
 455 05 5  
 456 65 X  
 457 43 RCL  
 458 07 07  
 459 85 +  
 460 04 4  
 461 01 1  
 462 93 .  
 463 03 3  
 464 03 3  
 465 65 X  
 466 43 RCL  
 467 07 07  
 468 33 X<sup>2</sup>  
 469 75 -  
 470 05 5  
 471 93 .  
 472 00 0  
 473 09 9  
 474 05 5  
 475 03 3  
 476 65 X  
 477 43 RCL  
 478 07 07  
 479 45 YX  
 480 03 3  
 481 75 -  
 482 53 ( )  
 483 01 1  
 484 05 5  
 485 04 4  
 486 93 .  
 487 09 9  
 488 08 8  
 489 75 -  
 490 02 2  
 491 01 1  
 492 07 7  
 493 93 .  
 494 05 5  
 495 01 1  
 496 65 X  
 497 43 RCL  
 498 07 07  
 499 85 +

500 02 2  
 501 06 6  
 502 01 1  
 503 93 .  
 504 07 7  
 505 03 3  
 506 65 X  
 507 43 RCL  
 508 07 07  
 509 33 X<sup>2</sup>  
 510 75 -  
 511 03 3  
 512 05 5  
 513 93 .  
 514 09 9  
 515 00 0  
 516 05 5  
 517 65 X  
 518 43 RCL  
 519 07 07  
 520 45 YX  
 521 03 3  
 522 54 ( )  
 523 65 X  
 524 43 RCL  
 525 05 05  
 526 85 +  
 527 53 ( )  
 528 04 4  
 529 00 0  
 530 05 5  
 531 93 .  
 532 00 0  
 533 08 8  
 534 75 -  
 535 05 5  
 536 02 2  
 537 05 5  
 538 93 .  
 539 05 5  
 540 06 6  
 541 65 X  
 542 43 RCL  
 543 07 07  
 544 85 +  
 545 06 6  
 546 00 0  
 547 07 7  
 548 93 .  
 549 04 4

550 09 9  
 551 65 X  
 552 43 RCL  
 553 07 07  
 554 33 X<sup>2</sup>  
 555 75 -  
 556 08 8  
 557 08 8  
 558 93 .  
 559 07 7  
 560 03 3  
 561 07 7  
 562 65 X  
 563 43 RCL  
 564 07 07  
 565 45 YX  
 566 03 3  
 567 54 ( )  
 568 65 X  
 569 43 RCL  
 570 05 05  
 571 33 X<sup>2</sup>  
 572 75 -  
 573 53 ( )  
 574 04 4  
 575 04 4  
 576 05 5  
 577 93 .  
 578 06 6  
 579 02 2  
 580 75 -  
 581 05 5  
 582 04 4  
 583 02 2  
 584 93 .  
 585 09 9  
 586 08 8  
 587 65 X  
 588 43 RCL  
 589 07 07  
 590 85 +  
 591 06 6  
 592 01 1  
 593 01 1  
 594 93 .  
 595 05 5  
 596 05 5  
 597 65 X  
 598 43 RCL  
 599 07 07



600 33 X²  
 601 75 -  
 602 09 9  
 603 02 2  
 604 93 .  
 605 08 8  
 606 09 9  
 607 04 4  
 608 65 X  
 609 43 RCL  
 610 07 07  
 611 45 YX  
 612 03 3  
 613 54 )  
 614 65 X  
 615 43 RCL  
 616 05 05  
 617 45 YX  
 618 03 3  
 619 85 +  
 620 53 (  
 621 01 1  
 622 08 8  
 623 04 4  
 624 93 .  
 625 07 7  
 626 08 8  
 627 75 -  
 628 02 2  
 629 00 0  
 630 04 4  
 631 93 .  
 632 04 4  
 633 02 2  
 634 65 X  
 635 43 RCL  
 636 07 07  
 637 85 +  
 638 02 2  
 639 02 2  
 640 05 5  
 641 93 .  
 642 08 8  
 643 09 9  
 644 65 X  
 645 43 RCL  
 646 07 07  
 647 33 X²  
 648 75 -  
 649 03 3

650 05 5  
 651 93 .  
 652 01 1  
 653 08 8  
 654 09 9  
 655 65 X  
 656 43 RCL  
 657 07 07  
 658 45 YX  
 659 03 3  
 660 54 )  
 661 65 X  
 662 43 RCL  
 663 05 05  
 664 45 YX  
 665 04 4  
 666 95 =  
 667 92 RTN  
 668 91 R/S  
 669 32 XIT  
 670 91 R/S  
 671 00 0  
 000 76 LBL  
 001 13 0  
 002 42 STO  
 003 02 02  
 004 32 XIT  
 005 42 STO  
 006 05 05  
 007 91 R/S  
 008 76 LBL  
 009 14 0  
 010 42 STO  
 011 03 03  
 012 91 R/S  
 013 76 LBL  
 014 15 E  
 015 42 STO  
 016 04 04  
 017 25 CLR  
 018 00 0  
 019 00 0  
 020 00 0  
 021 00 0  
 022 00 0  
 023 00 0  
 024 00 0  
 025 00 0  
 026 00 0

027 00 0  
 028 00 0  
 029 00 0  
 030 00 0  
 031 00 0  
 032 00 0  
 033 00 0  
 034 00 0  
 035 00 0  
 036 53 (  
 037 04 4  
 038 93 .  
 039 03 3  
 040 07 7  
 041 03 3  
 042 02 2  
 043 52 EE  
 044 94 +/-  
 045 03 3  
 046 85 +  
 047 93 .  
 048 00 0  
 049 02 2  
 050 07 7  
 051 07 7  
 052 04 4  
 053 03 3  
 054 65 X  
 055 43 RCL  
 056 02 02  
 057 54 )  
 058 65 X  
 059 43 RCL  
 060 03 03  
 061 33 X²  
 062 95 =  
 063 65 X  
 064 02 2  
 065 85 +  
 066 43 RCL  
 067 05 05  
 068 95 =  
 069 42 STO  
 070 06 06  
 071 55 +  
 072 02 2  
 073 95 =  
 074 59 INT  
 075 75 -  
 076 43 RCL



```

077 06 06
078 55 +
079 02 2
080 95 =
081 50 I×I
082 42 STD
083 07 07
084 43 RCL
085 06 06
086 55 +
087 02 2
088 95 =
089 59 INT
090 65 ×
091 02 2
092 95 =
093 42 STD
094 09 09
095 71 SBR
096 01 01
097 33 33
098 42 STD
099 08 08
100 43 RCL
101 06 06
102 55 +
103 02 2
104 95 =
105 59 INT
106 65 ×
107 02 2
108 95 =
109 85 +
110 02 2
111 95 =
112 42 STD
113 09 09
114 71 SBR
115 01 01
116 33 33
117 75 -
118 43 RCL
119 08 08
120 95 =
121 65 ×
122 43 RCL
123 07 07
124 85 +
125 43 RCL
126 08 08

```

```

127 95 =
128 42 STD
129 07 07
130 61 GTD
131 06 06
132 02 02
133 05 5
134 93 .
135 06 6
136 02 2
137 05 5
138 03 3
139 75 -
140 01 1
141 93 .
142 09 9
143 08 8
144 09 9
145 65 ×
146 43 RCL
147 09 09
148 85 +
149 03 3
150 93 .
151 00 0
152 02 2
153 05 5
154 02 2
155 65 ×
156 43 RCL
157 09 09
158 33 X²
159 75 -
160 01 1
161 93 .
162 00 0
163 07 7
164 06 6
165 01 1
166 65 ×
167 43 RCL
168 09 09
169 45 YX
170 03 3
171 85 +
172 93 .
173 01 1
174 07 7
175 06 6
176 07 7

```

```

177 06 6
178 65 ×
179 43 RCL
180 09 09
181 45 YX
182 04 4
183 75 -
184 93 .
185 00 0
186 01 1
187 03 3
188 00 0
189 09 9
190 05 5
191 65 ×
192 43 RCL
193 09 09
194 45 YX
195 05 5
196 85 +
197 03 3
198 93 .
199 05 5
200 02 2
201 06 6
202 52 EE
203 94 +/-
204 04 4
205 65 ×
206 43 RCL
207 09 09
208 45 YX
209 06 6
210 85 +
211 53 (
212 02 2
213 00 0
214 05 5
215 93 .
216 03 3
217 00 0
218 01 1
219 02 2
220 75 -
221 02 2
222 04 4
223 08 8
224 93 .
225 09 9
226 03 3

```





227	01	1
228	07	7
229	65	X
230	43	RCL
231	09	09
232	85	+
233	09	9
234	01	1
235	93	.
236	06	6
237	06	6
238	03	3
239	05	5
240	05	5
241	65	X
242	43	RCL
243	09	09
244	33	X²
245	75	-
246	01	1
247	05	5
248	93	.
249	05	5
250	05	5
251	02	2
252	01	1
253	08	8
254	65	X
255	43	RCL
256	09	09
257	45	YX
258	03	3
259	85	+
260	01	1
261	93	.
262	02	2
263	02	2
264	04	4
265	04	4
266	03	3
267	02	2
268	65	X
269	43	RCL
270	09	09
271	45	YX
272	04	4
273	75	-
274	93	.
275	00	0
276	03	3

277	09	9
278	05	5
279	03	3
280	03	3
281	03	3
282	65	X
283	43	RCL
284	09	09
285	45	YX
286	05	5
287	85	+
288	02	2
289	93	.
290	08	8
291	09	9
292	06	6
293	03	3
294	08	8
295	05	5
296	52	EE
297	94	+/-
298	04	4
299	65	X
300	43	RCL
301	09	09
302	45	YX
303	06	6
304	54	)
305	65	X
306	43	RCL
307	03	03
308	75	-
309	53	(
310	01	1
311	00	0
312	05	5
313	02	2
314	93	.
315	01	1
316	02	2
317	03	3
318	75	-
319	01	1
320	02	2
321	03	3
322	01	1
323	93	.
324	02	2
325	04	4
326	65	X

327	43	RCL
328	09	09
329	85	+
330	04	4
331	08	8
332	07	7
333	93	.
334	04	4
335	02	2
336	03	3
337	03	3
338	65	X
339	43	RCL
340	09	09
341	33	X²
342	75	-
343	09	9
344	01	1
345	93	.
346	06	6
347	05	5
348	02	2
349	02	2
350	65	X
351	43	RCL
352	09	09
353	45	YX
354	03	3
355	85	+
356	08	8
357	93	.
358	06	6
359	06	6
360	02	2
361	09	9
362	06	6
363	02	2
364	65	X
365	43	RCL
366	09	09
367	45	YX
368	04	4
369	75	-
370	93	.
371	03	3
372	09	9
373	05	5
374	03	3
375	09	9
376	07	7



377 04 4  
 378 65 x  
 379 43 RCL  
 380 09 09  
 381 45 YX  
 382 05 5  
 383 85 +  
 384 93 .  
 385 00 0  
 386 00 0  
 387 06 6  
 388 09 9  
 389 00 0  
 390 05 5  
 391 05 5  
 392 03 3  
 393 05 5  
 394 65 x  
 395 43 RCL  
 396 09 09  
 397 45 YX  
 398 06 6  
 399 54 )  
 400 65 x  
 401 43 RCL  
 402 03 03  
 403 33 X²  
 404 85 +  
 405 53 (   
 406 01 1  
 407 06 6  
 408 08 8  
 409 00 0  
 410 93 .  
 411 01 1  
 412 04 4  
 413 02 2  
 414 75 -  
 415 01 1  
 416 09 9  
 417 05 5  
 418 00 0  
 419 93 .  
 420 01 1  
 421 03 3  
 422 09 9  
 423 65 x  
 424 43 RCL  
 425 09 09  
 426 85 +

427 07 7  
 428 08 8  
 429 08 8  
 430 93 .  
 431 08 8  
 432 05 5  
 433 01 1  
 434 03 3  
 435 65 x  
 436 43 RCL  
 437 09 09  
 438 33 X²  
 439 75 -  
 440 01 1  
 441 05 5  
 442 02 2  
 443 93 .  
 444 05 5  
 445 07 7  
 446 03 3  
 447 03 3  
 448 65 x  
 449 43 RCL  
 450 09 09  
 451 45 YX  
 452 03 3  
 453 85 +  
 454 01 1  
 455 05 5  
 456 93 .  
 457 00 0  
 458 03 3  
 459 08 8  
 460 01 1  
 461 09 9  
 462 65 x  
 463 43 RCL  
 464 09 09  
 465 45 YX  
 466 04 4  
 467 75 -  
 468 93 .  
 469 07 7  
 470 02 2  
 471 07 7  
 472 04 4  
 473 01 1  
 474 03 3  
 475 09 9  
 476 65 x

477 43 RCL  
 478 09 09  
 479 45 YX  
 480 05 5  
 481 85 +  
 482 93 .  
 483 00 0  
 484 01 1  
 485 03 3  
 486 07 7  
 487 00 0  
 488 07 7  
 489 65 x  
 490 43 RCL  
 491 09 09  
 492 45 YX  
 493 06 6  
 494 54 )  
 495 65 x  
 496 43 RCL  
 497 03 03  
 498 45 YX  
 499 03 3  
 500 75 -  
 501 53 (   
 502 08 8  
 503 06 6  
 504 04 4  
 505 93 .  
 506 06 6  
 507 08 8  
 508 07 7  
 509 05 5  
 510 75 -  
 511 01 1  
 512 00 0  
 513 00 0  
 514 00 0  
 515 93 .  
 516 04 4  
 517 04 4  
 518 03 3  
 519 65 x  
 520 43 RCL  
 521 09 09  
 522 85 +  
 523 04 4  
 524 00 0  
 525 08 8  
 526 93 .



527 07 7  
528 04 4  
529 05 5  
530 01 1  
531 65 X  
532 43 RCL  
533 09 09  
534 33 X<sup>2</sup>  
535 75 -  
536 08 8  
537 00 0  
538 93 .  
539 00 0  
540 08 8  
541 03 3  
542 01 1  
543 04 4  
544 65 X  
545 43 RCL  
546 09 09  
547 45 YX  
548 03 3  
549 85 +  
550 08 8  
551 93 .  
552 00 0  
553 03 3  
554 09 9  
555 05 5  
556 08 8  
557 65 X  
558 43 RCL  
559 09 09  
560 45 YX  
561 04 4  
562 75 -  
563 93 .  
564 03 3  
565 09 9  
566 08 8  
567 02 2  
568 05 5  
569 02 2  
570 07 7  
571 65 X  
572 43 RCL  
573 09 09  
574 45 YX  
575 05 5  
576 85 +

577 93 .  
578 00 0  
579 00 0  
580 07 7  
581 07 7  
582 02 2  
583 00 0  
584 06 6  
585 01 1  
586 07 7  
587 65 X  
588 43 RCL  
589 09 09  
590 45 YX  
591 06 6  
592 54 )  
593 65 X  
594 43 RCL  
595 03 03  
596 45 YX  
597 04 4  
598 95 =  
599 42 STD  
600 05 05  
601 92 RTN  
602 04 4  
603 93 .  
604 09 9  
605 07 7  
606 04 4  
607 02 2  
608 65 X  
609 43 RCL  
610 07 07  
611 85 +  
612 07 7  
613 93 .  
614 09 9  
615 00 0  
616 04 4  
617 03 3  
618 52 EE  
619 94 +/-  
620 06 6  
621 65 X  
622 43 RCL  
623 07 07  
624 33 X<sup>2</sup>  
625 95 =  
626 42 STD

627 07 07  
628 22 INV  
629 52 EE  
630 65 X  
631 01 1  
632 00 0  
633 00 0  
634 95 =  
635 59 INT  
636 55 ÷  
637 01 1  
638 00 0  
639 00 0  
640 95 =  
641 91 R/S  
642 53 (   
643 06 6  
644 93 .  
645 04 4  
646 01 1  
647 07 7  
648 05 5  
649 85 +  
650 93 .  
651 00 0  
652 01 1  
653 00 0  
654 04 4  
655 02 2  
656 06 6  
657 65 X  
658 43 RCL  
659 04 04  
660 75 -  
661 06 6  
662 93 .  
663 08 8  
664 09 9  
665 02 2  
666 05 5  
667 52 EE  
668 94 +/-  
669 06 6  
670 65 X  
671 43 RCL  
672 04 04  
673 33 X<sup>2</sup>  
674 85 +  
675 04 4  
676 93 .



677	09	9
678	01	1
679	02	2
680	07	7
681	52	EE
682	94	+/-
683	07	7
684	65	x
685	43	RCL
686	04	04
687	33	X²
688	65	x
689	43	RCL
690	04	04
691	54	)
692	65	x
693	43	RCL
694	03	03
695	95	=
696	42	STO
697	08	08
698	93	.
699	01	1
700	65	x
701	43	RCL
702	07	07
703	65	x
704	43	RCL
705	08	08
706	95	=
707	65	x
708	01	1
709	00	0
710	00	0
711	00	0
712	95	=
713	59	INT
714	22	INV
715	52	EE
716	91	R/S





# USER INFORMATION FOR PROGRAM 2

Program: Takeoff Ground Roll Distance

Number of Steps: 1385

Computation Time: 48-50 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight
2	pressure altitude (ft.)	B	Pressure altitude
3	temperature (°C)	E	temperature
4	headwind (kts.)	2nd,D	headwind
5	relative humidity (%)	2nd,E	unusable number
6	---	R/S	unusable number
7	read in cards 3 & 4	R/S	---
8	---	2nd,A	unusable number
9	flap position (degrees)	2nd,B	flap position
0	center of gravity (%)	2nd,C	center of gravity
1	runway slope (%)	-	takeoff ground roll distance



000 76 LBL  
 001 12 8  
 002 42 STD  
 003 00 00  
 004 91 R/S  
 005 76 LBL  
 006 15 E  
 007 42 STD  
 008 01 01  
 009 91 R/S  
 010 76 LBL  
 011 11 A  
 012 42 STD  
 013 02 02  
 014 91 R/S  
 015 76 LBL  
 016 19 D'  
 017 42 STD  
 018 04 04  
 019 91 R/S  
 020 76 LBL  
 021 10 E'  
 022 42 STD  
 023 03 03  
 024 53 (  
 025 01 1  
 026 03 3  
 027 93 .  
 028 00 0  
 029 08 8  
 030 06 6  
 031 75 -  
 032 93 .  
 033 00 0  
 034 00 0  
 035 00 0  
 036 01 1  
 037 07 7  
 038 01 1  
 039 01 1  
 040 03 3  
 041 65 x  
 042 43 RCL  
 043 00 00  
 044 75 -  
 045 02 2  
 046 93 .  
 047 00 0  
 048 06 6  
 049 05 5

050 05 5  
 051 52 EE  
 052 94 +/-  
 053 07 7  
 054 65 x  
 055 43 RCL  
 056 00 00  
 057 33 X²  
 058 85 +  
 059 03 3  
 060 93 .  
 061 06 6  
 062 08 8  
 063 06 6  
 064 01 1  
 065 52 EE  
 066 94 +/-  
 067 01 1  
 068 01 1  
 069 65 x  
 070 43 RCL  
 071 00 00  
 072 45 YX  
 073 03 3  
 074 75 -  
 075 02 2  
 076 93 .  
 077 04 4  
 078 01 1  
 079 05 5  
 080 06 6  
 081 52 EE  
 082 94 +/-  
 083 01 1  
 084 05 5  
 085 65 x  
 086 43 RCL  
 087 00 00  
 088 45 YX  
 089 04 4  
 090 54 )  
 091 75 -  
 092 53 (  
 093 93 .  
 094 00 0  
 095 04 4  
 096 05 5  
 097 06 6  
 098 03 3  
 099 85 +

100 07 7  
 101 93 .  
 102 08 8  
 103 09 9  
 104 03 3  
 105 01 1  
 106 52 EE  
 107 94 +/-  
 108 06 6  
 109 65 x  
 110 43 RCL  
 111 00 00  
 112 75 -  
 113 03 3  
 114 93 .  
 115 07 7  
 116 05 5  
 117 04 4  
 118 05 5  
 119 52 EE  
 120 94 +/-  
 121 09 9  
 122 65 x  
 123 43 RCL  
 124 00 00  
 125 33 X²  
 126 85 +  
 127 09 9  
 128 93 .  
 129 07 7  
 130 00 0  
 131 08 8  
 132 08 8  
 133 52 EE  
 134 94 +/-  
 135 01 1  
 136 03 3  
 137 65 x  
 138 43 RCL  
 139 00 00  
 140 45 YX  
 141 03 3  
 142 75 -  
 143 06 6  
 144 93 .  
 145 09 9  
 146 09 9  
 147 07 7  
 148 52 EE  
 149 94 +/-



150	01	1
151	07	7
152	65	X
153	43	RCL
154	00	00
155	45	YX
156	04	4
157	54	)
158	65	X
159	53	(
160	43	RCL
161	01	01
162	54	)
163	75	-
164	53	(
165	93	.
166	00	0
167	00	0
168	01	1
169	03	3
170	01	1
171	07	7
172	85	+
173	08	8
174	93	.
175	02	2
176	05	5
177	05	5
178	08	8
179	52	EE
180	94	+/-
181	07	7
182	65	X
183	43	RCL
184	00	00
185	75	-
186	04	4
187	93	.
188	00	0
189	07	7
190	03	3
191	09	9
192	02	2
193	52	EE
194	94	+/-
195	01	1
196	00	0
197	65	X
198	43	RCL
199	00	00

200	33	X²
201	85	+
202	08	8
203	93	.
204	05	5
205	04	4
206	08	8
207	08	8
208	52	EE
209	94	+/-
210	01	1
211	04	4
212	65	X
213	43	RCL
214	00	00
215	45	YX
216	03	3
217	75	-
218	05	5
219	93	.
220	04	4
221	09	9
222	06	6
223	04	4
224	52	EE
225	94	+/-
226	01	1
227	08	8
228	65	X
229	43	RCL
230	00	00
231	45	YX
232	04	4
233	54	)
234	65	X
235	53	(
236	43	RCL
237	01	01
238	33	X²
239	54	)
240	75	-
241	53	(
242	01	1
243	93	.
244	09	9
245	00	0
246	09	9
247	07	7
248	52	EE
249	94	+/-

250	05	5
251	75	-
252	01	1
253	93	.
254	03	3
255	06	6
256	07	7
257	01	1
258	52	EE
259	94	+/-
260	08	8
261	65	X
262	43	RCL
263	00	00
264	85	+
265	09	9
266	93	.
267	04	4
268	06	6
269	09	9
270	04	4
271	52	EE
272	94	+/-
273	01	1
274	02	2
275	65	X
276	43	RCL
277	00	00
278	33	X²
279	75	-
280	02	2
281	93	.
282	00	0
283	04	4
284	03	3
285	04	4
286	52	EE
287	94	+/-
288	01	1
289	05	5
290	65	X
291	43	RCL
292	00	00
293	45	YX
294	03	3
295	85	+
296	01	1
297	93	.
298	04	4
299	06	6



300 01 1  
 301 07 7  
 302 52 EE  
 303 94 +/-  
 304 01 1  
 305 09 9  
 306 65 X  
 307 43 RCL  
 308 00 00  
 309 45 YX  
 310 04 4  
 311 54 )  
 312 65 X  
 313 53 (  
 314 43 RCL  
 315 01 01  
 316 45 YX  
 317 03 3  
 318 54 )  
 319 95 =  
 320 65 X  
 321 93 .  
 322 05 5  
 323 06 6  
 324 06 6  
 325 85 +  
 326 01 1  
 327 93 .  
 328 09 9  
 329 09 9  
 330 07 7  
 331 03 3  
 332 95 =  
 333 65 X  
 334 53 (  
 335 05 5  
 336 93 .  
 337 08 8  
 338 06 6  
 339 02 2  
 340 01 1  
 341 52 EE  
 342 04 4  
 343 75 -  
 344 01 1  
 345 00 0  
 346 93 .  
 347 01 1  
 348 04 4  
 349 06 6

350 65 X  
 351 43 RCL  
 352 02 02  
 353 85 +  
 354 06 6  
 355 93 .  
 356 08 8  
 357 08 8  
 358 00 0  
 359 07 7  
 360 52 EE  
 361 94 +/-  
 362 04 4  
 363 65 X  
 364 43 RCL  
 365 02 02  
 366 33 X<sup>2</sup>  
 367 75 -  
 368 02 2  
 369 93 .  
 370 02 2  
 371 09 9  
 372 02 2  
 373 52 EE  
 374 94 +/-  
 375 08 8  
 376 65 X  
 377 43 RCL  
 378 02 02  
 379 45 YX  
 380 03 3  
 381 85 +  
 382 03 3  
 383 93 .  
 384 07 7  
 385 03 3  
 386 08 8  
 387 07 7  
 388 52 EE  
 389 94 +/-  
 390 01 1  
 391 03 3  
 392 65 X  
 393 43 RCL  
 394 02 02  
 395 45 YX  
 396 04 4  
 397 75 -  
 398 02 2  
 399 93 .

400 03 3  
 401 09 9  
 402 06 6  
 403 04 4  
 404 52 EE  
 405 94 +/-  
 406 01 1  
 407 08 8  
 408 65 X  
 409 43 RCL  
 410 02 02  
 411 45 YX  
 412 05 5  
 413 54 )  
 414 75 -  
 415 53 (  
 416 04 4  
 417 93 .  
 418 08 8  
 419 08 8  
 420 09 9  
 421 06 6  
 422 52 EE  
 423 05 5  
 424 75 -  
 425 08 8  
 426 04 4  
 427 93 .  
 428 09 9  
 429 07 7  
 430 04 4  
 431 65 X  
 432 43 RCL  
 433 02 02  
 434 85 +  
 435 05 5  
 436 93 .  
 437 07 7  
 438 08 8  
 439 05 5  
 440 06 6  
 441 52 EE  
 442 94 +/-  
 443 03 3  
 444 65 X  
 445 43 RCL  
 446 02 02  
 447 33 X<sup>2</sup>  
 448 75 -  
 449 01 1





450 93 .  
 451 09 9  
 452 03 3  
 453 07 7  
 454 03 3  
 455 52 EE  
 456 94 +/-  
 457 07 7  
 458 65 x  
 459 43 RCL  
 460 02 02  
 461 45 YX  
 462 03 3  
 463 85 +  
 464 03 3  
 465 93 .  
 466 01 1  
 467 07 7  
 468 04 4  
 469 04 4  
 470 52 EE  
 471 94 +/-  
 472 01 1  
 473 02 2  
 474 65 x  
 475 43 RCL  
 476 02 02  
 477 45 YX  
 478 04 4  
 479 75 -  
 480 02 2  
 481 93 .  
 482 00 0  
 483 04 4  
 484 04 4  
 485 06 6  
 486 52 EE  
 487 94 +/-  
 488 01 1  
 489 07 7  
 490 65 x  
 491 43 RCL  
 492 02 02  
 493 45 YX  
 494 05 5  
 495 54 )  
 496 95 =  
 497 42 STO  
 498 09 09  
 499 43 RCL

500 03 03  
 501 32 X:T  
 502 04 4  
 503 00 0  
 504 22 INV  
 505 77 GE  
 506 05 05  
 507 13 13  
 508 25 CLR  
 509 04 4  
 510 00 0  
 511 42 STO  
 512 03 03  
 513 43 RCL  
 514 09 09  
 515 65 x  
 516 53 (  
 517 01 1  
 518 85 +  
 519 53 (  
 520 43 RCL  
 521 03 03  
 522 75 -  
 523 04 4  
 524 00 0  
 525 54 )  
 526 55 +  
 527 01 1  
 528 00 0  
 529 00 0  
 530 00 0  
 531 54 )  
 532 95 =  
 533 42 STO  
 534 09 09  
 535 06 6  
 536 07 7  
 537 93 .  
 538 01 1  
 539 02 2  
 540 04 4  
 541 85 +  
 542 93 .  
 543 08 8  
 544 09 9  
 545 05 5  
 546 00 0  
 547 09 9  
 548 65 x  
 549 43 RCL

550 09 09  
 551 85 +  
 552 02 2  
 553 93 .  
 554 03 3  
 555 03 3  
 556 00 0  
 557 06 6  
 558 52 EE  
 559 94 +/-  
 560 05 5  
 561 65 x  
 562 43 RCL  
 563 09 09  
 564 33 X<sup>2</sup>  
 565 75 -  
 566 01 1  
 567 93 .  
 568 06 6  
 569 02 2  
 570 05 5  
 571 04 4  
 572 52 EE  
 573 94 +/-  
 574 09 9  
 575 65 x  
 576 43 RCL  
 577 09 09  
 578 45 YX  
 579 03 3  
 580 85 +  
 581 03 3  
 582 93 .  
 583 03 3  
 584 07 7  
 585 02 2  
 586 08 8  
 587 52 EE  
 588 94 +/-  
 589 01 1  
 590 04 4  
 591 65 x  
 592 43 RCL  
 593 09 09  
 594 45 YX  
 595 04 4  
 596 75 -  
 597 53 (  
 598 09 9  
 599 93 .



600	00	0
601	09	9
602	09	9
603	05	5
604	85	+
605	93	.
606	00	0
607	01	1
608	00	0
609	08	8
610	05	5
611	06	6
612	65	x
613	43	RCL
614	09	09
615	75	-
616	02	2
617	93	.
618	01	1
619	07	7
620	05	5
621	04	4
622	52	EE
623	94	+/-
624	07	7
625	65	x
626	43	RCL
627	09	09
628	33	X²
629	85	+
630	02	2
631	93	.
632	05	5
633	03	3
634	02	2
635	07	7
636	52	EE
637	94	+/-
638	01	1
639	01	1
640	65	x
641	43	RCL
642	09	09
643	45	YX
644	03	3
645	75	-
646	01	1
647	93	.
648	01	1
649	09	9

650	07	7
651	52	EE
652	94	+/-
653	01	1
654	05	5
655	65	x
656	43	RCL
657	09	09
658	45	YX
659	04	4
660	54	)
661	65	x
662	43	RCL
663	04	04
664	85	+
665	53	(
666	93	.
667	01	1
668	04	4
669	07	7
670	08	8
671	02	2
672	75	-
673	02	2
674	93	.
675	01	1
676	06	6
677	06	6
678	06	6
679	52	EE
680	94	+/-
681	06	6
682	65	x
683	43	RCL
684	09	09
685	85	+
686	03	3
687	93	.
688	04	4
689	02	2
690	07	7
691	04	4
692	52	EE
693	94	+/-
694	09	9
695	65	x
696	43	RCL
697	09	09
698	33	X²
699	75	-

700	02	2
701	93	.
702	07	7
703	08	8
704	01	1
705	07	7
706	52	EE
707	94	+/-
708	01	1
709	03	3
710	65	x
711	43	RCL
712	09	09
713	45	YX
714	03	3
715	85	+
716	09	9
717	93	.
718	03	3
719	00	0
720	07	7
721	07	7
722	52	EE
723	94	+/-
724	01	1
725	08	8
726	65	x
727	43	RCL
728	09	09
729	45	YX
730	04	4
731	54	)
732	65	x
733	43	RCL
734	04	04
735	33	X²
736	95	=
737	91	R/S
738	32	X!T
739	91	R/S
740	00	0
741	00	0
000	32	X!T
001	42	STD
002	09	09
003	91	R/S
004	76	L8L
005	16	R'
006	42	STD
007	07	07



008 91 R/S  
 009 76 LBL  
 010 17 B'  
 011 42 STD  
 012 06 06  
 013 91 R/S  
 014 76 LBL  
 015 18 C'  
 016 42 STD  
 017 05 05  
 018 53 (  
 019 04 4  
 020 05 5  
 021 93 .  
 022 07 7  
 023 00 0  
 024 04 4  
 025 85 +  
 026 93 .  
 027 09 9  
 028 03 3  
 029 04 4  
 030 02 2  
 031 09 9  
 032 65 x  
 033 43 RCL  
 034 09 09  
 035 85 +  
 036 02 2  
 037 93 .  
 038 02 2  
 039 02 2  
 040 06 6  
 041 05 5  
 042 52 EE  
 043 94 +/-  
 044 05 5  
 045 65 x  
 046 43 RCL  
 047 09 09  
 048 33 X<sup>2</sup>  
 049 75 -  
 050 02 2  
 051 93 .  
 052 03 3  
 053 03 3  
 054 08 8  
 055 52 EE  
 056 94 +/-  
 057 09 9

058 65 x  
 059 43 RCL  
 060 09 09  
 061 45 YX  
 062 03 3  
 063 85 +  
 064 07 7  
 065 93 .  
 066 09 9  
 067 04 4  
 068 01 1  
 069 52 EE  
 070 94 +/-  
 071 01 1  
 072 04 4  
 073 65 x  
 074 43 RCL  
 075 09 09  
 076 45 YX  
 077 04 4  
 078 54 )  
 079 85 +  
 080 53 (  
 081 07 7  
 082 93 .  
 083 09 9  
 084 04 4  
 085 07 7  
 086 02 2  
 087 85 +  
 088 01 1  
 089 93 .  
 090 04 4  
 091 09 9  
 092 01 1  
 093 04 4  
 094 52 EE  
 095 94 +/-  
 096 02 2  
 097 65 x  
 098 43 RCL  
 099 09 09  
 100 85 +  
 101 09 9  
 102 93 .  
 103 00 0  
 104 07 7  
 105 00 0  
 106 07 7  
 107 52 EE

108 94 +/-  
 109 06 6  
 110 65 x  
 111 43 RCL  
 112 09 09  
 113 33 X<sup>2</sup>  
 114 75 -  
 115 07 7  
 116 93 .  
 117 01 1  
 118 02 2  
 119 03 3  
 120 05 5  
 121 52 EE  
 122 94 +/-  
 123 01 1  
 124 00 0  
 125 65 x  
 126 43 RCL  
 127 09 09  
 128 45 YX  
 129 03 3  
 130 85 +  
 131 03 3  
 132 93 .  
 133 00 0  
 134 06 6  
 135 08 8  
 136 04 4  
 137 52 EE  
 138 94 +/-  
 139 01 1  
 140 04 4  
 141 65 x  
 142 43 RCL  
 143 09 09  
 144 45 YX  
 145 04 4  
 146 54 )  
 147 65 x  
 148 43 RCL  
 149 05 05  
 150 85 +  
 151 53 (  
 152 05 5  
 153 93 .  
 154 03 3  
 155 06 6  
 156 01 1  
 157 06 6



158 75 -  
 159 08 8  
 160 93 .  
 161 05 5  
 162 01 1  
 163 03 3  
 164 06 6  
 165 52 EE  
 166 94 +/-  
 167 03 3  
 168 65 x  
 169 43 RCL  
 170 09 09  
 171 85 +  
 172 03 3  
 173 93 .  
 174 05 5  
 175 09 9  
 176 01 1  
 177 04 4  
 178 52 EE  
 179 94 +/-  
 180 06 6  
 181 65 x  
 182 43 RCL  
 183 09 09  
 184 33 X²  
 185 75 -  
 186 04 4  
 187 93 .  
 188 05 5  
 189 09 9  
 190 03 3  
 191 02 2  
 192 52 EE  
 193 94 +/-  
 194 01 1  
 195 00 0  
 196 65 x  
 197 43 RCL  
 198 09 09  
 199 45 YX  
 200 03 3  
 201 85 +  
 202 01 1  
 203 93 .  
 204 09 9  
 205 08 8  
 206 08 8  
 207 09 9

208 52 EE  
 209 94 +/-  
 210 01 1  
 211 04 4  
 212 65 x  
 213 43 RCL  
 214 09 09  
 215 45 YX  
 216 04 4  
 217 54 )  
 218 65 x  
 219 53 (  
 220 43 RCL  
 221 05 05  
 222 33 X²  
 223 54 )  
 224 95 =  
 225 42 STO  
 226 09 09  
 227 53 (  
 228 02 2  
 229 93 .  
 230 06 6  
 231 00 0  
 232 04 4  
 233 02 2  
 234 52 EE  
 235 03 3  
 236 75 -  
 237 02 2  
 238 93 .  
 239 01 1  
 240 06 6  
 241 09 9  
 242 04 4  
 243 65 x  
 244 43 RCL  
 245 09 09  
 246 85 +  
 247 01 1  
 248 93 .  
 249 00 0  
 250 09 9  
 251 01 1  
 252 05 5  
 253 52 EE  
 254 94 +/-  
 255 03 3  
 256 65 x  
 257 43 RCL

258 09 09  
 259 33 X²  
 260 75 -  
 261 01 1  
 262 93 .  
 263 01 1  
 264 01 1  
 265 01 1  
 266 09 9  
 267 52 EE  
 268 94 +/-  
 269 07 7  
 270 65 x  
 271 43 RCL  
 272 09 09  
 273 45 YX  
 274 03 3  
 275 85 +  
 276 03 3  
 277 93 .  
 278 06 6  
 279 06 6  
 280 02 2  
 281 52 EE  
 282 94 +/-  
 283 01 1  
 284 02 2  
 285 65 x  
 286 43 RCL  
 287 09 09  
 288 45 YX  
 289 04 4  
 290 54 )  
 291 75 -  
 292 53 (  
 293 01 1  
 294 93 .  
 295 07 7  
 296 05 5  
 297 07 7  
 298 03 3  
 299 52 EE  
 300 02 2  
 301 75 -  
 302 93 .  
 303 02 2  
 304 02 2  
 305 06 6  
 306 00 0  
 307 01 1





308 65 x  
 309 43 RCL  
 310 09 09  
 311 85 +  
 312 07 7  
 313 93 .  
 314 05 5  
 315 02 2  
 316 02 2  
 317 05 5  
 318 52 EE  
 319 94 +/-  
 320 05 5  
 321 65 x  
 322 43 RCL  
 323 09 09  
 324 33 X²  
 325 75 -  
 326 07 7  
 327 93 .  
 328 07 7  
 329 00 0  
 330 01 1  
 331 08 8  
 332 52 EE  
 333 94 +/-  
 334 09 9  
 335 65 x  
 336 43 RCL  
 337 09 09  
 338 45 YX  
 339 03 3  
 340 85 +  
 341 02 2  
 342 93 .  
 343 05 5  
 344 04 4  
 345 03 3  
 346 07 7  
 347 52 EE  
 348 94 +/-  
 349 01 1  
 350 03 3  
 351 65 x  
 352 43 RCL  
 353 09 09  
 354 45 YX  
 355 04 4  
 356 54 )  
 357 65 x

358 43 RCL  
 359 06 06  
 360 85 +  
 361 53 (  
 362 02 2  
 363 93 .  
 364 08 8  
 365 05 5  
 366 04 4  
 367 09 9  
 368 75 -  
 369 04 4  
 370 93 .  
 371 00 0  
 372 01 1  
 373 00 0  
 374 02 2  
 375 52 EE  
 376 94 +/-  
 377 03 3  
 378 65 x  
 379 43 RCL  
 380 09 09  
 381 85 +  
 382 01 1  
 383 93 .  
 384 02 2  
 385 08 8  
 386 03 3  
 387 02 2  
 388 52 EE  
 389 94 +/-  
 390 06 6  
 391 65 x  
 392 43 RCL  
 393 09 09  
 394 33 X²  
 395 75 -  
 396 01 1  
 397 93 .  
 398 03 3  
 399 02 2  
 400 03 3  
 401 04 4  
 402 52 EE  
 403 94 +/-  
 404 01 1  
 405 00 0  
 406 65 x  
 407 43 RCL

408 09 09  
 409 45 YX  
 410 03 3  
 411 85 +  
 412 04 4  
 413 93 .  
 414 03 3  
 415 09 9  
 416 00 0  
 417 08 8  
 418 52 EE  
 419 94 +/-  
 420 01 1  
 421 05 5  
 422 65 x  
 423 43 RCL  
 424 09 09  
 425 45 YX  
 426 04 4  
 427 54 )  
 428 65 x  
 429 53 (  
 430 43 RCL  
 431 06 06  
 432 33 X²  
 433 54 )  
 434 95 =  
 435 42 STD  
 436 09 09  
 437 25 CLR  
 438 75 -  
 439 53 (  
 440 04 4  
 441 00 0  
 442 00 0  
 443 93 .  
 444 07 7  
 445 09 9  
 446 75 -  
 447 01 1  
 448 93 .  
 449 05 5  
 450 08 8  
 451 00 0  
 452 01 1  
 453 65 x  
 454 43 RCL  
 455 09 09  
 456 85 +  
 457 02 2



458	93	.
459	00	0
460	02	2
461	05	5
462	04	4
463	52	EE
464	94	+/-
465	04	4
466	65	x
467	43	RCL
468	09	09
469	33	X²
470	75	-
471	02	2
472	93	.
473	04	4
474	01	1
475	01	1
476	01	1
477	52	EE
478	94	+/-
479	08	8
480	65	x
481	43	RCL
482	09	09
483	45	YX
484	03	3
485	85	+
486	08	8
487	93	.
488	06	6
489	07	7
490	03	3
491	07	7
492	52	EE
493	94	+/-
494	01	1
495	03	3
496	65	x
497	43	RCL
498	09	09
499	45	YX
500	04	4
501	54	)
502	85	+
503	53	(
504	01	1
505	06	6
506	93	.
507	01	1

508	09	9
509	06	6
510	75	-
511	93	.
512	00	0
513	02	2
514	04	4
515	03	3
516	03	3
517	03	3
518	65	x
519	43	RCL
520	09	09
521	85	+
522	09	9
523	93	.
524	03	3
525	04	4
526	08	8
527	04	4
528	52	EE
529	94	+/-
530	06	6
531	65	x
532	43	RCL
533	09	09
534	33	X²
535	75	-
536	01	1
537	93	.
538	02	2
539	05	5
540	09	9
541	04	4
542	52	EE
543	94	+/-
544	09	9
545	65	x
546	43	RCL
547	09	09
548	45	YX
549	03	3
550	85	+
551	04	4
552	93	.
553	07	7
554	05	5
555	02	2
556	02	2
557	52	EE

558	94	+/-
559	01	1
560	04	4
561	65	x
562	43	RCL
563	09	09
564	45	YX
565	04	4
566	54	)
567	65	x
568	43	RCL
569	07	07
570	75	-
571	53	(
572	93	.
573	01	1
574	04	4
575	07	7
576	05	5
577	08	8
578	75	-
579	02	2
580	93	.
581	03	3
582	05	5
583	09	9
584	52	EE
585	94	+/-
586	04	4
587	65	x
588	43	RCL
589	09	09
590	85	+
591	01	1
592	93	.
593	00	0
594	03	3
595	07	7
596	52	EE
597	94	+/-
598	07	7
599	65	x
600	43	RCL
601	09	09
602	33	X²
603	75	-
604	01	1
605	93	.
606	06	6
607	00	0



```

608 01 1
609 06 6
610 52 EE
611 94 +/-
612 01 1
613 01 1
614 65 X
615 43 RCL
616 09 09
617 45 YX
618 03 3
619 85 +
620 06 6
621 93 .
622 03 3
623 01 1
624 09 9
625 05 5
626 52 EE
627 94 +/-
628 01 1
629 06 6
630 65 X
631 43 RCL
632 09 09
633 45 YX
634 04 4
635 54 )
636 65 X
637 53 (
638 43 RCL
639 07 07
640 33 X²
641 54 )
642 95 =
643 59 INT
644 22 INV
645 52 EE
646 91 R/S
647 00 0
648 00 0
649 00 0

```



# USER INFORMATION FOR PROGRAM 3

Program: Maximum Range Time and Speed at Constant Altitude

Number of Steps: . 547

Computation Time: 20 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	altitude (ft.)	B	altitude/1000
3	drag count	C	drag count
4	temperature (°C)	E	temperature
5	distance (nautical miles)	2nd,B	distance
6	headwind (kts.)	2nd,C	mach number
7	---	R/S	ground speed (kts.)
8	---	R/S	time required (minutes)





```

000 76 LBL
001 11 A
002 55 ÷
003 01 1
004 00 0
005 00 0
006 00 0
007 95 =
008 42 STD
009 00 00
010 91 R/S
011 76 LBL
012 12 8
013 55 ÷
014 01 1
015 00 0
016 00 0
017 00 0
018 95 =
019 42 STD
020 01 01
021 91 R/S
022 76 LBL
023 13 C
024 42 STD
025 02 02
026 91 R/S
027 76 LBL
028 15 E
029 42 STD
030 03 03
031 91 R/S
032 76 LBL
033 17 8'
034 42 STD
035 05 05
036 91 R/S
037 76 LBL
038 19 D'
039 42 STD
040 04 04
041 25 CLR
042 75 -
043 01 1
044 85 +
045 05 5
046 93 .
047 00 0
048 07 7
049 09 9

```

```

050 04 4
051 52 EE
052 94 +/-
053 03 3
054 65 x
055 43 RCL
056 01 01
057 75 -
058 01 1
059 93 .
060 03 3
061 09 9
062 06 6
063 08 8
064 52 EE
065 94 +/-
066 03 3
067 65 x
068 43 RCL
069 01 01
070 33 X²
071 85 +
072 08 8
073 93 .
074 02 2
075 05 5
076 04 4
077 52 EE
078 94 +/-
079 05 5
080 65 x
081 43 RCL
082 01 01
083 45 YX
084 03 3
085 75 -
086 01 1
087 93 .
088 02 2
089 06 6
090 09 9
091 08 8
092 52 EE
093 94 +/-
094 06 6
095 65 x
096 43 RCL
097 01 01
098 45 YX
099 04 4

```

```

100 85 +
101 53 (
102 93 .
103 00 0
104 05 5
105 85 +
106 93 .
107 00 0
108 00 0
109 01 1
110 05 5
111 01 1
112 05 5
113 09 9
114 65 x
115 43 RCL
116 01 01
117 85 +
118 01 1
119 93 .
120 01 1
121 02 2
122 03 3
123 52 EE
124 94 +/-
125 04 4
126 65 x
127 43 RCL
128 01 01
129 33 X²
130 75 -
131 03 3
132 93 .
133 04 4
134 09 9
135 02 2
136 01 1
137 52 EE
138 94 +/-
139 06 6
140 65 x
141 43 RCL
142 01 01
143 45 YX
144 03 3
145 85 +
146 07 7
147 93 .
148 09 9
149 03 3

```



150 06 6  
 151 05 5  
 152 52 EE  
 153 94 +/-  
 154 08 8  
 155 65 x  
 156 43 RCL  
 157 01 01  
 158 45 YX  
 159 04 4  
 160 54 )  
 161 65 x  
 162 43 RCL  
 163 00 00  
 164 95 =  
 165 42 STD  
 166 06 06  
 167 25 CLR  
 168 93 .  
 169 04 4  
 170 07 7  
 171 08 8  
 172 00 0  
 173 03 3  
 174 75 -  
 175 93 .  
 176 00 0  
 177 00 0  
 178 01 1  
 179 03 3  
 180 04 4  
 181 01 1  
 182 07 7  
 183 65 x  
 184 43 RCL  
 185 02 02  
 186 85 +  
 187 06 6  
 188 93 .  
 189 02 2  
 190 02 2  
 191 08 8  
 192 07 7  
 193 52 EE  
 194 94 +/-  
 195 06 6  
 196 65 x  
 197 43 RCL  
 198 02 02  
 199 33 X<sup>2</sup>

200 75 -  
 201 01 1  
 202 93 .  
 203 06 6  
 204 02 2  
 205 06 6  
 206 01 1  
 207 52 EE  
 208 94 +/-  
 209 08 8  
 210 65 x  
 211 43 RCL  
 212 02 02  
 213 45 YX  
 214 03 3  
 215 85 +  
 216 01 1  
 217 93 .  
 218 06 6  
 219 04 4  
 220 03 3  
 221 08 8  
 222 52 EE  
 223 94 +/-  
 224 01 1  
 225 01 1  
 226 65 x  
 227 43 RCL  
 228 02 02  
 229 45 YX  
 230 04 4  
 231 85 +  
 232 53 (   
 233 93 .  
 234 00 0  
 235 08 8  
 236 02 2  
 237 01 1  
 238 07 7  
 239 85 +  
 240 04 4  
 241 93 .  
 242 01 1  
 243 02 2  
 244 00 0  
 245 09 9  
 246 52 EE  
 247 94 +/-  
 248 04 4  
 249 65 x

250 43 RCL  
 251 02 02  
 252 75 -  
 253 04 4  
 254 93 .  
 255 05 5  
 256 05 5  
 257 07 7  
 258 07 7  
 259 52 EE  
 260 94 +/-  
 261 06 6  
 262 65 x  
 263 43 RCL  
 264 02 02  
 265 33 X<sup>2</sup>  
 266 85 +  
 267 01 1  
 268 93 .  
 269 06 6  
 270 07 7  
 271 07 7  
 272 07 7  
 273 52 EE  
 274 94 +/-  
 275 08 8  
 276 65 x  
 277 43 RCL  
 278 02 02  
 279 45 YX  
 280 03 3  
 281 75 -  
 282 02 2  
 283 93 .  
 284 00 0  
 285 00 0  
 286 01 1  
 287 52 EE  
 288 94 +/-  
 289 01 1  
 290 01 1  
 291 65 x  
 292 43 RCL  
 293 02 02  
 294 45 YX  
 295 04 4  
 296 54 )  
 297 65 x  
 298 43 RCL  
 299 06 06



300 85 +  
 301 53 (  
 302 93 .  
 303 00 0  
 304 00 0  
 305 00 0  
 306 04 4  
 307 02 2  
 308 01 1  
 309 04 4  
 310 03 3  
 311 75 -  
 312 09 9  
 313 93 .  
 314 04 4  
 315 03 3  
 316 09 9  
 317 07 7  
 318 52 EE  
 319 94 +/-  
 320 05 5  
 321 65 x  
 322 43 RCL  
 323 02 02  
 324 85 +  
 325 01 1  
 326 93 .  
 327 02 2  
 328 06 6  
 329 04 4  
 330 06 6  
 331 52 EE  
 332 94 +/-  
 333 06 6  
 334 65 x  
 335 43 RCL  
 336 02 02  
 337 33 X<sup>2</sup>  
 338 75 -  
 339 04 4  
 340 93 .  
 341 08 8  
 342 05 5  
 343 03 3  
 344 07 7  
 345 52 EE  
 346 94 +/-  
 347 09 9  
 348 65 x  
 349 43 RCL

350 02 02  
 351 45 YX  
 352 03 3  
 353 85 +  
 354 05 5  
 355 93 .  
 356 07 7  
 357 02 2  
 358 02 2  
 359 02 2  
 360 52 EE  
 361 94 +/-  
 362 01 1  
 363 02 2  
 364 65 x  
 365 43 RCL  
 366 02 02  
 367 45 YX  
 368 04 4  
 369 54 )  
 370 65 x  
 371 53 (  
 372 43 RCL  
 373 06 06  
 374 33 X<sup>2</sup>  
 375 54 )  
 376 75 -  
 377 53 (  
 378 06 6  
 379 93 .  
 380 06 6  
 381 07 7  
 382 06 6  
 383 07 7  
 384 52 EE  
 385 94 +/-  
 386 04 4  
 387 75 -  
 388 08 8  
 389 93 .  
 390 04 4  
 391 06 6  
 392 07 7  
 393 01 1  
 394 52 EE  
 395 94 +/-  
 396 06 6  
 397 65 x  
 398 43 RCL  
 399 02 02

400 85 +  
 401 01 1  
 402 93 .  
 403 00 0  
 404 05 5  
 405 00 0  
 406 01 1  
 407 52 EE  
 408 94 +/-  
 409 07 7  
 410 65 x  
 411 43 RCL  
 412 02 02  
 413 33 X<sup>2</sup>  
 414 75 -  
 415 03 3  
 416 93 .  
 417 06 6  
 418 03 3  
 419 08 8  
 420 02 2  
 421 52 EE  
 422 94 +/-  
 423 01 1  
 424 00 0  
 425 65 x  
 426 43 RCL  
 427 02 02  
 428 45 YX  
 429 03 3  
 430 85 +  
 431 03 3  
 432 93 .  
 433 07 7  
 434 08 8  
 435 02 2  
 436 08 8  
 437 52 EE  
 438 94 +/-  
 439 01 1  
 440 03 3  
 441 65 x  
 442 43 RCL  
 443 02 02  
 444 45 YX  
 445 04 4  
 446 54 )  
 447 65 x  
 448 53 (  
 449 43 RCL



450	06	06	500	53	(
451	45	YX	501	53	(
452	03	3	502	07	7
453	54	)	503	01	1
454	95	=	504	00	0
455	42	STO	505	54	)
456	07	07	506	65	X
457	65	X	507	53	(
458	01	1	508	43	RCL
459	00	0	509	08	08
460	00	0	510	75	-
461	00	0	511	93	.
462	95	=	512	01	1
463	22	INV	513	04	4
464	52	EE	514	54	)
465	59	INT	515	85	+
466	55	÷	516	01	1
467	01	1	517	00	0
468	00	0	518	00	0
469	00	0	519	75	-
470	00	0	520	43	RCL
471	95	=	521	04	04
472	91	R/S	522	54	)
473	43	RCL	523	95	=
474	07	07	524	42	STO
475	75	-	525	09	09
476	53	(	526	59	INT
477	53	(	527	91	R/S
478	06	6	528	43	RCL
479	00	0	529	09	09
480	75	-	530	35	1/X
481	43	RCL	531	65	X
482	03	03	532	43	RCL
483	54	)	533	05	05
484	65	X	534	65	X
485	53	(	535	06	6
486	02	2	536	00	0
487	65	X	537	95	=
488	43	RCL	538	65	X
489	07	07	539	01	1
490	54	)	540	00	0
491	55	÷	541	95	=
492	01	1	542	59	INT
493	02	2	543	55	÷
494	00	0	544	01	1
495	00	0	545	00	0
496	54	)	546	95	=
497	95	=	547	91	R/S
498	42	STO			
499	08	08			





# USER INFORMATION FOR PROGRAM 4

Program: Maximum Range Fuel Required at Constant Altitude

Number of Steps: 439

Computation Time: 16 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	altitude (ft.)	B	altitude/1000
3	drag count	C	drag count
4	true air speed (kts.)	2nd,D	true airspeed
5	time (minutes)	2nd,E	(lb.fuel required/ nautical miles)
6	---	R/S	fuel flow required
7	---	R/S	fuel required



000 76 LBL  
 001 11 A  
 002 55 +  
 003 01 1  
 004 00 0  
 005 00 0  
 006 00 0  
 007 95 =  
 008 42 STD  
 009 00 00  
 010 91 R/S  
 011 76 LBL  
 012 12 B  
 013 55 +  
 014 01 1  
 015 00 0  
 016 00 0  
 017 00 0  
 018 95 =  
 019 42 STD  
 020 01 01  
 021 91 R/S  
 022 76 LBL  
 023 13 C  
 024 42 STD  
 025 02 02  
 026 91 R/S  
 027 76 LBL  
 028 19 D'  
 029 42 STD  
 030 03 03  
 031 91 R/S  
 032 76 LBL  
 033 10 E'  
 034 42 STD  
 035 04 04  
 036 53 (   
 037 04 4  
 038 93 .  
 039 05 5  
 040 04 4  
 041 75 -  
 042 93 .  
 043 01 1  
 044 06 6  
 045 04 4  
 046 04 4  
 047 04 4  
 048 65 x  
 049 43 RCL

050 01 01  
 051 85 +  
 052 93 .  
 053 00 0  
 054 00 0  
 055 03 3  
 056 03 3  
 057 09 9  
 058 03 3  
 059 02 2  
 060 65 x  
 061 43 RCL  
 062 01 01  
 063 33 X<sup>2</sup>  
 064 75 -  
 065 01 1  
 066 93 .  
 067 00 0  
 068 02 2  
 069 08 8  
 070 03 3  
 071 52 EE  
 072 94 +/-  
 073 04 4  
 074 65 x  
 075 43 RCL  
 076 01 01  
 077 45 YX  
 078 03 3  
 079 85 +  
 080 01 1  
 081 93 .  
 082 09 9  
 083 02 2  
 084 06 6  
 085 52 EE  
 086 94 +/-  
 087 06 6  
 088 65 x  
 089 43 RCL  
 090 01 01  
 091 45 YX  
 092 04 4  
 093 75 -  
 094 01 1  
 095 93 .  
 096 03 3  
 097 07 7  
 098 05 5  
 099 07 7

100 52 EE  
 101 94 +/-  
 102 08 8  
 103 65 x  
 104 43 RCL  
 105 01 01  
 106 45 YX  
 107 05 5  
 108 54 )  
 109 85 +  
 110 53 (   
 111 03 3  
 112 93 .  
 113 02 2  
 114 03 3  
 115 52 EE  
 116 94 +/-  
 117 09 9  
 118 75 -  
 119 03 3  
 120 93 .  
 121 06 6  
 122 06 6  
 123 06 6  
 124 04 4  
 125 52 EE  
 126 94 +/-  
 127 03 3  
 128 65 x  
 129 43 RCL  
 130 01 01  
 131 85 +  
 132 08 8  
 133 93 .  
 134 09 9  
 135 03 3  
 136 03 3  
 137 08 8  
 138 52 EE  
 139 94 +/-  
 140 04 4  
 141 65 x  
 142 43 RCL  
 143 01 01  
 144 33 X<sup>2</sup>  
 145 75 -  
 146 05 5  
 147 93 .  
 148 05 5  
 149 09 9



150 03 3  
 151 09 9  
 152 52 EE  
 153 94 +/-  
 154 05 5  
 155 65 x  
 156 43 RCL  
 157 01 01  
 158 45 YX  
 159 03 3  
 160 85 +  
 161 01 1  
 162 93 .  
 163 04 4  
 164 05 5  
 165 09 9  
 166 03 3  
 167 52 EE  
 168 94 +/-  
 169 06 6  
 170 65 x  
 171 43 RCL  
 172 01 01  
 173 45 YX  
 174 04 4  
 175 75 -  
 176 01 1  
 177 93 .  
 178 03 3  
 179 02 2  
 180 08 8  
 181 01 1  
 182 52 EE  
 183 94 +/-  
 184 08 8  
 185 65 x  
 186 43 RCL  
 187 01 01  
 188 45 YX  
 189 05 5  
 190 54 )  
 191 65 x  
 192 43 RCL  
 193 00 00  
 194 85 +  
 195 53 (<  
 196 06 6  
 197 52 EE  
 198 94 +/-  
 199 04 4

200 85 +  
 201 01 1  
 202 93 .  
 203 01 1  
 204 02 2  
 205 00 0  
 206 03 3  
 207 52 EE  
 208 94 +/-  
 209 04 4  
 210 65 x  
 211 43 RCL  
 212 01 01  
 213 75 -  
 214 02 2  
 215 93 .  
 216 03 3  
 217 03 3  
 218 05 5  
 219 08 8  
 220 52 EE  
 221 94 +/-  
 222 05 5  
 223 65 x  
 224 43 RCL  
 225 01 01  
 226 33 X²  
 227 85 +  
 228 01 1  
 229 93 .  
 230 04 4  
 231 05 5  
 232 03 3  
 233 06 6  
 234 52 EE  
 235 94 +/-  
 236 06 6  
 237 65 x  
 238 43 RCL  
 239 01 01  
 240 45 YX  
 241 03 3  
 242 75 -  
 243 03 3  
 244 93 .  
 245 07 7  
 246 01 1  
 247 04 4  
 248 04 4  
 249 52 EE

250 94 +/-  
 251 08 8  
 252 65 x  
 253 43 RCL  
 254 01 01  
 255 45 YX  
 256 04 4  
 257 85 +  
 258 03 3  
 259 93 .  
 260 03 3  
 261 03 3  
 262 03 3  
 263 04 4  
 264 52 EE  
 265 94 +/-  
 266 01 1  
 267 00 0  
 268 65 x  
 269 43 RCL  
 270 01 01  
 271 45 YX  
 272 05 5  
 273 54 )  
 274 65 x  
 275 43 RCL  
 276 00 00  
 277 33 X²  
 278 95 =  
 279 42 STD  
 280 05 05  
 281 01 1  
 282 93 .  
 283 04 4  
 284 02 2  
 285 05 5  
 286 01 1  
 287 52 EE  
 288 94 +/-  
 289 01 1  
 290 00 0  
 291 65 x  
 292 43 RCL  
 293 02 02  
 294 45 YX  
 295 04 4  
 296 75 -  
 297 02 2  
 298 93 .  
 299 03 3



300 05 5  
 301 01 1  
 302 06 6  
 303 52 EE  
 304 94 +/-  
 305 07 7  
 306 65 x  
 307 43 RCL  
 308 02 02  
 309 45 YX  
 310 03 3  
 311 85 +  
 312 09 9  
 313 93 .  
 314 07 7  
 315 02 2  
 316 09 9  
 317 09 9  
 318 52 EE  
 319 94 +/-  
 320 05 5  
 321 65 x  
 322 43 RCL  
 323 02 02  
 324 33 X<sup>2</sup>  
 325 75 -  
 326 02 2  
 327 93 .  
 328 05 5  
 329 03 3  
 330 09 9  
 331 09 9  
 332 52 EE  
 333 94 +/-  
 334 03 3  
 335 65 x  
 336 43 RCL  
 337 02 02  
 338 85 +  
 339 53 (   
 340 02 2  
 341 85 +  
 342 93 .  
 343 00 0  
 344 00 0  
 345 04 4  
 346 02 2  
 347 03 3  
 348 08 8  
 349 08 8

350 65 x  
 351 43 RCL  
 352 02 02  
 353 85 +  
 354 01 1  
 355 93 .  
 356 02 2  
 357 03 3  
 358 02 2  
 359 06 6  
 360 52 EE  
 361 94 +/-  
 362 05 5  
 363 65 x  
 364 43 RCL  
 365 02 02  
 366 33 X<sup>2</sup>  
 367 75 -  
 368 01 1  
 369 93 .  
 370 00 0  
 371 02 2  
 372 09 9  
 373 08 8  
 374 52 EE  
 375 94 +/-  
 376 07 7  
 377 65 x  
 378 43 RCL  
 379 02 02  
 380 45 YX  
 381 03 3  
 382 85 +  
 383 01 1  
 384 93 .  
 385 07 7  
 386 02 2  
 387 07 7  
 388 07 7  
 389 52 EE  
 390 94 +/-  
 391 01 1  
 392 00 0  
 393 65 x  
 394 43 RCL  
 395 02 02  
 396 45 YX  
 397 04 4  
 398 54 )  
 399 65 x

400 43 RCL  
 401 05 05  
 402 95 =  
 403 42 STD  
 404 09 09  
 405 65 x  
 406 01 1  
 407 52 EE  
 408 03 3  
 409 95 =  
 410 59 INT  
 411 55 +  
 412 01 1  
 413 52 EE  
 414 03 3  
 415 95 =  
 416 22 INV  
 417 52 EE  
 418 91 R/S  
 419 43 RCL  
 420 09 09  
 421 65 x  
 422 43 RCL  
 423 03 03  
 424 95 =  
 425 42 STD  
 426 09 09  
 427 59 INT  
 428 91 R/S  
 429 43 RCL  
 430 09 09  
 431 65 x  
 432 43 RCL  
 433 04 04  
 434 55 +  
 435 06 6  
 436 00 0  
 437 95 =  
 438 59 INT  
 439 91 R/S





USER INFORMATION FOR PROGRAM 5

Program: Military Climb Schedule

Number of Steps: 195

Computation Time: 3 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	altitude (ft.)	B	altitude
3	drag count	C	drag count
4	temperature (°C)	E	indicated airspeed (kts. below 20000 ft.)
5	---	R/S	mach number (above 20000 ft.)



000 76 LBL  
 001 11 A  
 002 42 STD  
 003 01 01  
 004 91 R/S  
 005 76 LBL  
 006 12 B  
 007 42 STD  
 008 02 02  
 009 91 R/S  
 010 76 LBL  
 011 13 C  
 012 42 STD  
 013 00 00  
 014 91 R/S  
 015 76 LBL  
 016 15 E  
 017 42 STD  
 018 03 03  
 019 25 CLR  
 020 04 4  
 021 00 0  
 022 05 5  
 023 93 .  
 024 05 5  
 025 08 8  
 026 75 -  
 027 93 .  
 028 07 7  
 029 09 9  
 030 00 0  
 031 07 7  
 032 05 5  
 033 65 x  
 034 43 RCL  
 035 00 00  
 036 85 +  
 037 93 .  
 038 00 0  
 039 00 0  
 040 01 1  
 041 01 1  
 042 03 3  
 043 08 8  
 044 02 2  
 045 65 x  
 046 43 RCL  
 047 00 00  
 048 33 X²  
 049 75 -

050 04 4  
 051 93 .  
 052 01 1  
 053 00 0  
 054 01 1  
 055 08 8  
 056 52 EE  
 057 94 +/-  
 058 07 7  
 059 65 x  
 060 43 RCL  
 061 00 00  
 062 45 YX  
 063 03 3  
 064 95 =  
 065 22 INV  
 066 52 EE  
 067 59 INT  
 068 91 R/S  
 069 25 CLR  
 070 93 .  
 071 08 8  
 072 06 6  
 073 75 -  
 074 02 2  
 075 93 .  
 076 01 1  
 077 06 6  
 078 03 3  
 079 04 4  
 080 52 EE  
 081 94 +/-  
 082 03 3  
 083 65 x  
 084 43 RCL  
 085 00 00  
 086 85 +  
 087 07 7  
 088 93 .  
 089 06 6  
 090 05 5  
 091 08 8  
 092 02 2  
 093 52 EE  
 094 94 +/-  
 095 05 5  
 096 65 x  
 097 43 RCL  
 098 00 00  
 099 33 X²

100 75 -  
 101 01 1  
 102 93 .  
 103 01 1  
 104 03 3  
 105 04 4  
 106 04 4  
 107 52 EE  
 108 94 +/-  
 109 06 6  
 110 65 x  
 111 43 RCL  
 112 00 00  
 113 45 YX  
 114 03 3  
 115 85 +  
 116 07 7  
 117 93 .  
 118 02 2  
 119 01 1  
 120 02 2  
 121 05 5  
 122 52 EE  
 123 94 +/-  
 124 09 9  
 125 65 x  
 126 43 RCL  
 127 00 00  
 128 45 YX  
 129 04 4  
 130 75 -  
 131 02 2  
 132 93 .  
 133 03 3  
 134 00 0  
 135 03 3  
 136 05 5  
 137 52 EE  
 138 94 +/-  
 139 01 1  
 140 01 1  
 141 65 x  
 142 43 RCL  
 143 00 00  
 144 45 YX  
 145 05 5  
 146 85 +  
 147 03 3  
 148 93 .  
 149 06 6



150	05	5
151	08	8
152	08	8
153	52	EE
154	94	+/-
155	01	1
156	04	4
157	65	x
158	43	RCL
159	00	00
160	45	YX
161	06	6
162	75	-
163	02	2
164	93	.
165	03	3
166	00	0
167	06	6
168	02	2
169	52	EE
170	94	+/-
171	01	1
172	07	7
173	65	x
174	43	RCL
175	00	00
176	45	YX
177	07	7
178	95	=
179	65	x
180	01	1
181	00	0
182	00	0
183	00	0
184	95	=
185	32	INV
186	52	EE
187	59	INT
188	95	=
189	55	÷
190	01	1
191	00	0
192	00	0
193	00	0
194	95	=
195	91	R/S



USER INFORMATION FOR PROGRAM 6

Program: Takeoff Airspeed

Number of Steps: 265

Computation Time: 9 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight
2	flap position (degrees)	2nd,A	flap position
3	center of gravity (%)	2nd,B	takeoff airspeed (kts)





```

000 76 LBL
001 11 R
002 42 STD
003 00 00
004 91 R/S
005 76 LBL
006 16 R'
007 42 STD
008 02 02
009 91 R/S
010 76 LBL
011 17 S'
012 42 STD
013 01 01
014 53 (
015 05 5
016 04 4
017 93 .
018 00 0
019 02 2
020 03 3
021 65 +
022 03 3
023 93 .
024 04 4
025 07 7
026 08 8
027 07 7
028 52 EE
029 94 +/-
030 03 3
031 65 x
032 43 RCL
033 00 00
034 75 -
035 01 1
036 93 .
037 09 9
038 04 4
039 07 7
040 05 5
041 52 EE
042 94 +/-
043 08 8
044 65 x
045 43 RCL
046 00 00
047 33 X²
048 54 )
049 85 +

```

```

050 53 (
051 53 (
052 02 2
053 06 6
054 75 -
055 43 RCL
056 01 01
057 54 )
058 55 -
059 02 2
060 54 )
061 95 =
062 42 STD
063 03 03
064 25 CLR
065 75 -
066 53 (
067 01 1
068 93 .
069 09 9
070 01 1
071 07 7
072 01 1
073 52 EE
074 03 3
075 75 -
076 06 6
077 01 1
078 93 .
079 06 6
080 00 0
081 04 4
082 65 x
083 43 RCL
084 03 03
085 85 +
086 93 .
087 07 7
088 00 0
089 03 3
090 04 4
091 08 8
092 65 x
093 43 RCL
094 03 03
095 33 X²
096 75 -
097 03 3
098 93 .
099 05 5

```

```

100 06 6
101 06 6
102 01 1
103 52 EE
104 94 +/-
105 03 3
106 65 x
107 43 RCL
108 03 03
109 45 YX
110 03 3
111 85 +
112 06 6
113 93 .
114 06 6
115 05 5
116 07 7
117 08 8
118 52 EE
119 94 +/-
120 06 6
121 65 x
122 43 RCL
123 03 03
124 45 YX
125 04 4
126 54 )
127 85 +
128 53 (
129 07 7
130 06 6
131 93 .
132 08 8
133 02 2
134 04 4
135 75 -
136 02 2
137 93 .
138 04 4
139 05 5
140 01 1
141 07 7
142 65 x
143 43 RCL
144 03 03
145 85 +
146 02 2
147 93 .
148 08 8
149 07 7

```



150	07	7
151	09	9
152	52	EE
153	94	+/-
154	02	2
155	65	X
156	43	RCL
157	03	03
158	33	X <sup>2</sup>
159	75	-
160	01	1
161	93	.
162	04	4
163	07	7
164	05	5
165	03	3
166	52	EE
167	94	+/-
168	04	4
169	65	X
170	43	RCL
171	03	03
172	45	YX
173	03	3
174	85	+
175	02	2
176	93	.
177	07	7
178	08	8
179	07	7
180	02	2
181	52	EE
182	94	+/-
183	07	7
184	65	X
185	43	RCL
186	03	03
187	45	YX
188	04	4
189	54	)
190	65	X
191	43	RCL
192	02	02
193	75	-
194	53	(
195	93	.
196	07	7
197	02	2
198	02	2
199	03	3

200	09	9
201	75	-
202	93	.
203	00	0
204	02	2
205	03	3
206	04	4
207	01	1
208	05	5
209	65	X
210	43	RCL
211	03	03
212	85	+
213	02	2
214	93	.
215	07	7
216	09	9
217	08	8
218	52	EE
219	94	+/-
220	04	4
221	65	X
222	43	RCL
223	03	03
224	33	X <sup>2</sup>
225	75	-
226	01	1
227	93	.
228	04	4
229	05	5
230	09	9
231	06	6
232	52	EE
233	94	+/-
234	06	6
235	65	X
236	43	RCL
237	03	03
238	45	YX
239	03	3
240	85	+
241	02	2
242	93	.
243	08	8
244	00	0
245	07	7
246	52	EE
247	94	+/-
248	09	9
249	65	X

250	43	RCL
251	03	03
252	45	YX
253	04	4
254	54	)
255	65	X
256	53	(
257	43	RCL
258	02	02
259	33	X <sup>2</sup>
260	54	)
261	95	=
262	22	INV
263	52	EE
264	59	INT
265	91	R/S



USER INFORMATION FOR PROGRAM 7

Program: Maximum Refusal Speed

Number of Steps: 716

Computation Time: 26 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	runway altitude (ft.)	B	runway altitude
3	temperature (°C)	E	temperature
4	runway length (ft.)	2nd,C	maximum refusal speed



```

000 76 LBL
001 12 B
002 42 STD
003 00 00
004 91 R/S
005 76 LBL
006 15 E
007 42 STD
008 01 01
009 91 R/S
010 76 LBL
011 11 A
012 55 +
013 01 1
014 00 0
015 00 0
016 00 0
017 95 =
018 42 STD
019 02 02
020 91 R/S
021 76 LBL
022 18 C'
023 55 +
024 01 1
025 00 0
026 00 0
027 00 0
028 95 =
029 42 STD
030 03 03
031 53 (
032 01 1
033 03 3
034 93 .
035 00 0
036 08 8
037 06 6
038 75 -
039 93 .
040 00 0
041 00 0
042 00 0
043 01 1
044 07 7
045 01 1
046 01 1
047 03 3
048 65 X
049 43 RCL

```

```

050 00 00
051 75 -
052 02 2
053 93 .
054 00 0
055 06 6
056 05 5
057 05 5
058 52 EE
059 94 +/-
060 07 7
061 65 X
062 43 RCL
063 00 00
064 33 X^2
065 85 +
066 03 3
067 93 .
068 06 6
069 08 8
070 06 6
071 01 1
072 52 EE
073 94 +/-
074 01 1
075 01 1
076 65 X
077 43 RCL
078 00 00
079 45 YX
080 03 3
081 75 -
082 02 2
083 93 .
084 04 4
085 01 1
086 05 5
087 06 6
088 52 EE
089 94 +/-
090 01 1
091 05 5
092 65 X
093 43 RCL
094 00 00
095 45 YX
096 04 4
097 54 )
098 75 -
099 53 (

```

```

100 93 .
101 00 0
102 04 4
103 05 5
104 06 6
105 03 3
106 85 +
107 07 7
108 93 .
109 08 8
110 09 9
111 03 3
112 01 1
113 52 EE
114 94 +/-
115 06 6
116 65 X
117 43 RCL
118 00 00
119 75 -
120 03 3
121 93 .
122 07 7
123 05 5
124 04 4
125 05 5
126 52 EE
127 94 +/-
128 09 9
129 65 X
130 43 RCL
131 00 00
132 33 X^2
133 85 +
134 09 9
135 93 .
136 07 7
137 00 0
138 08 8
139 08 8
140 52 EE
141 94 +/-
142 01 1
143 03 3
144 65 X
145 43 RCL
146 00 00
147 45 YX
148 03 3
149 75 -

```





150	06	6
151	93	.
152	09	9
153	09	9
154	07	7
155	52	EE
156	94	+/-
157	01	1
158	07	7
159	65	x
160	43	RCL
161	00	00
162	45	YX
163	04	4
164	54	)
165	65	x
166	53	(
167	43	RCL
168	01	01
169	54	)
170	75	-
171	53	(
172	93	.
173	00	0
174	00	0
175	01	1
176	03	3
177	01	1
178	07	7
179	65	+
180	08	8
181	93	.
182	02	2
183	05	5
184	05	5
185	08	8
186	52	EE
187	94	+/-
188	07	7
189	65	x
190	43	RCL
191	00	00
192	75	-
193	04	4
194	93	.
195	00	0
196	07	7
197	03	3
198	09	9
199	02	2

200	52	EE
201	94	+/-
202	01	1
203	00	0
204	65	x
205	43	RCL
206	00	00
207	33	X²
208	85	+
209	08	8
210	93	.
211	05	5
212	04	4
213	08	8
214	08	8
215	52	EE
216	94	+/-
217	01	1
218	04	4
219	65	x
220	43	RCL
221	00	00
222	45	YX
223	03	3
224	75	-
225	05	5
226	93	.
227	04	4
228	09	9
229	06	6
230	04	4
231	52	EE
232	94	+/-
233	01	1
234	08	8
235	65	x
236	43	RCL
237	00	00
238	45	YX
239	04	4
240	54	)
241	65	x
242	53	(
243	43	RCL
244	01	01
245	33	X²
246	54	)
247	75	-
248	53	(
249	01	1

250	93	.
251	09	9
252	00	0
253	09	9
254	07	7
255	52	EE
256	94	+/-
257	05	5
258	75	-
259	01	1
260	93	.
261	03	3
262	06	6
263	07	7
264	01	1
265	52	EE
266	94	+/-
267	06	6
268	65	x
269	43	RCL
270	00	00
271	85	+
272	09	9
273	93	.
274	04	4
275	06	6
276	09	9
277	04	4
278	52	EE
279	94	+/-
280	01	1
281	02	2
282	65	x
283	43	RCL
284	00	00
285	33	X²
286	75	-
287	02	2
288	93	.
289	00	0
290	04	4
291	03	3
292	04	4
293	52	EE
294	94	+/-
295	01	1
296	05	5
297	65	x
298	43	RCL
299	00	00



300 45 YX  
 301 03 3  
 302 85 +  
 303 01 1  
 304 93 .  
 305 04 4  
 306 06 6  
 307 01 1  
 308 07 7  
 309 52 EE  
 310 94 +/-  
 311 01 1  
 312 09 9  
 313 65 X  
 314 43 RCL  
 315 00 00  
 316 45 YX  
 317 04 4  
 318 54 )  
 319 65 X  
 320 53 (  
 321 43 RCL  
 322 01 01  
 323 45 YX  
 324 03 3  
 325 54 )  
 326 95 =  
 327 65 X  
 328 93 .  
 329 05 5  
 330 06 6  
 331 06 6  
 332 85 +  
 333 01 1  
 334 93 .  
 335 09 9  
 336 09 9  
 337 07 7  
 338 03 3  
 339 95 =  
 340 42 STO  
 341 04 04  
 342 53 (  
 343 04 4  
 344 03 3  
 345 93 .  
 346 00 0  
 347 01 1  
 348 94 +/-  
 349 85 +

350 06 6  
 351 93 .  
 352 07 7  
 353 06 6  
 354 01 1  
 355 65 X  
 356 43 RCL  
 357 02 02  
 358 75 -  
 359 93 .  
 360 03 3  
 361 05 5  
 362 01 1  
 363 05 5  
 364 09 9  
 365 65 X  
 366 43 RCL  
 367 02 02  
 368 33 X<sup>2</sup>  
 369 85 +  
 370 93 .  
 371 00 0  
 372 00 0  
 373 08 8  
 374 00 0  
 375 05 5  
 376 04 4  
 377 05 5  
 378 65 X  
 379 43 RCL  
 380 02 02  
 381 45 YX  
 382 03 3  
 383 75 -  
 384 06 6  
 385 93 .  
 386 07 7  
 387 07 7  
 388 06 6  
 389 09 9  
 390 52 EE  
 391 94 +/-  
 392 05 5  
 393 65 X  
 394 43 RCL  
 395 02 02  
 396 45 YX  
 397 04 4  
 398 54 )  
 399 85 +

400 53 (  
 401 02 2  
 402 06 6  
 403 93 .  
 404 03 3  
 405 01 1  
 406 02 2  
 407 75 -  
 408 03 3  
 409 93 .  
 410 08 8  
 411 03 3  
 412 08 8  
 413 02 2  
 414 65 X  
 415 43 RCL  
 416 02 02  
 417 85 +  
 418 93 .  
 419 93 .  
 420 02 2  
 421 00 0  
 422 03 3  
 423 02 2  
 424 06 6  
 425 65 X  
 426 43 RCL  
 427 02 02  
 428 33 X<sup>2</sup>  
 429 75 -  
 430 93 .  
 431 00 0  
 432 00 0  
 433 04 4  
 434 07 7  
 435 00 0  
 436 02 2  
 437 02 2  
 438 65 X  
 439 43 RCL  
 440 02 02  
 441 45 YX  
 442 03 3  
 443 85 +  
 444 03 3  
 445 93 .  
 446 09 9  
 447 09 9  
 448 04 4  
 449 52 EE



450 94 +/-  
 451 05 5  
 452 65 X  
 453 43 RCL  
 454 02 02  
 455 45 YX  
 456 04 4  
 457 54 )  
 458 65 X  
 459 43 RCL  
 460 04 04  
 461 75 -  
 462 53 (  
 463 04 4  
 464 93 .  
 465 09 9  
 466 06 6  
 467 03 3  
 468 09 9  
 469 75 -  
 470 93 .  
 471 07 7  
 472 02 2  
 473 07 7  
 474 02 2  
 475 03 3  
 476 65 X  
 477 43 RCL  
 478 02 02  
 479 85 +  
 480 93 .  
 481 00 0  
 482 03 3  
 483 08 8  
 484 07 7  
 485 02 2  
 486 01 1  
 487 65 X  
 488 43 RCL  
 489 02 02  
 490 33 X<sup>2</sup>  
 491 75 -  
 492 08 8  
 493 93 .  
 494 09 9  
 495 08 8  
 496 05 5  
 497 52 EE  
 498 94 +/-  
 499 04 4

500 65 X  
 501 43 RCL  
 502 02 02  
 503 45 YX  
 504 03 3  
 505 85 +  
 506 07 7  
 507 93 .  
 508 06 6  
 509 03 3  
 510 08 8  
 511 52 EE  
 512 94 +/-  
 513 06 6  
 514 65 X  
 515 43 RCL  
 516 02 02  
 517 45 YX  
 518 04 4  
 519 54 )  
 520 65 X  
 521 53 (  
 522 43 RCL  
 523 04 04  
 524 33 X<sup>2</sup>  
 525 54 )  
 526 85 +  
 527 53 (  
 528 93 .  
 529 03 3  
 530 00 0  
 531 02 2  
 532 08 8  
 533 08 8  
 534 75 -  
 535 93 .  
 536 00 0  
 537 04 4  
 538 04 4  
 539 08 8  
 540 05 5  
 541 05 5  
 542 65 X  
 543 43 RCL  
 544 02 02  
 545 85 +  
 546 93 .  
 547 00 0  
 548 00 0  
 549 02 2

550 03 3  
 551 09 9  
 552 02 2  
 553 01 1  
 554 65 X  
 555 43 RCL  
 556 02 02  
 557 33 X<sup>2</sup>  
 558 75 -  
 559 05 5  
 560 93 .  
 561 05 5  
 562 05 5  
 563 04 4  
 564 09 9  
 565 52 EE  
 566 94 +/-  
 567 05 5  
 568 65 X  
 569 53 (  
 570 43 RCL  
 571 02 02  
 572 45 YX  
 573 03 3  
 574 54 )  
 575 85 +  
 576 04 4  
 577 93 .  
 578 07 7  
 579 02 2  
 580 01 1  
 581 07 7  
 582 52 EE  
 583 94 +/-  
 584 07 7  
 585 65 X  
 586 53 (  
 587 43 RCL  
 588 02 02  
 589 45 YX  
 590 04 4  
 591 54 )  
 592 54 )  
 593 65 X  
 594 53 (  
 595 43 RCL  
 596 04 04  
 597 45 YX  
 598 03 3  
 599 54 )



600	95	=
601	65	x
602	53	(
603	93	.
604	02	2
605	08	8
606	01	1
607	01	1
608	94	+/-
609	75	-
610	04	4
611	93	.
612	02	2
613	00	0
614	01	1
615	02	2
616	65	x
617	43	RCL
618	03	03
619	85	+
620	93	.
621	07	7
622	00	0
623	03	3
624	07	7
625	07	7
626	65	x
627	43	RCL
628	03	03
629	33	X²
630	75	-
631	93	.
632	00	0
633	05	5
634	08	8
635	06	6
636	09	9
637	03	3
638	65	x
639	43	RCL
640	03	03
641	45	YX
642	03	3
643	85	+
644	93	.
645	00	0
646	00	0
647	01	1
648	07	7
649	04	4

650	06	6
651	01	1
652	65	x
653	43	RCL
654	03	03
655	45	YX
656	04	4
657	54	5
658	75	-
659	01	1
660	01	1
661	93	.
662	04	4
663	01	1
664	02	2
665	85	+
666	06	6
667	02	2
668	93	.
669	01	1
670	08	8
671	05	5
672	65	x
673	43	RCL
674	03	03
675	75	-
676	09	9
677	93	.
678	00	0
679	00	0
680	03	3
681	07	7
682	65	x
683	43	RCL
684	03	03
685	33	X²
686	85	+
687	93	.
688	06	6
689	04	4
690	09	9
691	02	2
692	01	1
693	65	x
694	43	RCL
695	03	03
696	45	YX
697	03	3
698	75	-
699	93	.

700	00	0
701	01	1
702	07	7
703	04	4
704	05	5
705	05	5
706	65	x
707	43	RCL
708	03	03
709	45	YX
710	04	4
711	95	=
712	22	INV
713	52	EE
714	59	INT
715	95	=
716	91	R/S





USER INFORMATION FOR PROGRAM 8

Program: Optimum Endurance Altitude

Number of Steps: 229

Computation Time: 8 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	drag count	C	optimum endurance altitude (ft.)



```

000 76 LBL
001 11 A
002 55 +
003 01 1
004 00 0
005 00 0
006 00 0
007 95 =
008 42 STO
009 00 00
010 91 R/S
011 76 LBL
012 13 C
013 42 STO
014 01 01
015 25 CLR
016 05 5
017 05 5
018 93 .
019 03 3
020 03 3
021 03 3
022 03 3
023 85 +
024 93 .
025 00 0
026 07 7
027 03 3
028 00 0
029 07 7
030 06 6
031 65 x
032 43 RCL
033 01 01
034 75 -
035 09 9
036 93 .
037 07 7
038 08 8
039 03 3
040 06 6
041 52 EE
042 94 +/-
043 04 4
044 65 x
045 43 RCL
046 01 01
047 33 X²
048 85 +
049 03 3

```

```

050 93 .
051 05 5
052 00 0
053 01 1
054 05 5
055 52 EE
056 94 +/-
057 06 6
058 65 x
059 43 RCL
060 01 01
061 45 YX
062 03 3
063 75 -
064 03 3
065 93 .
066 09 9
067 07 7
068 08 8
069 02 2
070 52 EE
071 94 +/-
072 09 9
073 65 x
074 43 RCL
075 01 01
076 45 YX
077 04 4
078 75 -
079 53 (
080 01 1
081 93 .
082 01 1
083 85 +
084 08 8
085 93 .
086 00 0
087 05 5
088 09 9
089 07 7
090 52 EE
091 94 +/-
092 03 3
093 65 x
094 43 RCL
095 01 01
096 75 -
097 08 8
098 93 .
099 00 0

```

```

100 00 0
101 09 9
102 07 7
103 52 EE
104 94 +/-
105 05 5
106 65 x
107 43 RCL
108 01 01
109 33 X²
110 85 +
111 02 2
112 93 .
113 08 8
114 08 8
115 03 3
116 06 6
117 52 EE
118 94 +/-
119 07 7
120 65 x
121 43 RCL
122 01 01
123 45 YX
124 03 3
125 75 -
126 03 3
127 93 .
128 03 3
129 00 0
130 03 3
131 02 2
132 52 EE
133 94 +/-
134 01 1
135 00 0
136 65 x
137 43 RCL
138 01 01
139 45 YX
140 04 4
141 54 )
142 65 x
143 43 RCL
144 00 00
145 85 +
146 53 (
147 06 6
148 93 .
149 06 6

```



150	06	6		200	93	.
151	06	6		201	00	0
152	07	7		202	02	2
153	52	EE		203	01	1
154	94	+/-		204	08	8
155	03	3		205	52	EE
156	85	+		206	94	+/-
157	01	1		207	01	1
158	93	.		208	02	2
159	02	2		209	65	x
160	05	5		210	43	RCL
161	04	4		211	01	01
162	01	1		212	45	Yx
163	52	EE		213	04	4
164	94	+/-		214	54	)
165	04	4		215	65	x
166	65	x		216	43	RCL
167	43	RCL		217	00	00
168	01	01		218	33	X <sup>2</sup>
169	75	-		219	95	=
170	01	1		220	65	x
171	93	.		221	01	1
172	04	4		222	00	0
173	00	0		223	00	0
174	03	3		224	00	0
175	09	9		225	95	=
176	52	EE		226	59	INT
177	94	+/-		227	22	INV
178	06	6		228	57	ENG
179	65	x		229	91	R/S
180	43	RCL				
181	01	01				
182	33	X <sup>2</sup>				
183	85	+				
184	05	5				
185	93	.				
186	02	2				
187	00	0				
188	03	3				
189	02	2				
190	52	EE				
191	94	+/-				
192	09	9				
193	65	x				
194	43	RCL				
195	01	01				
196	45	Yx				
197	03	3				
198	75	-				
199	06	6				



USER INFORMATION FOR PROGRAM 9

Program: Cruise Ceiling

Number of Steps: 299

Computation Time: 11 seconds

<u>STEP</u>	<u>ENTER</u>	<u>PRESS KEY</u>	<u>DISPLAY</u>
1	gross weight (lbs.)	A	gross weight/1000
2	drag count	C	cruise ceiling





```

000 76 L&L
001 11 A
002 55 +
003 01 1
004 00 0
005 00 0
006 00 0
007 95 =
008 42 STD
009 00 00
010 91 R/S
011 76 L&L
012 13 C
013 42 STD
014 01 01
015 25 CLR
016 08 8
017 05 5
018 93 .
019 01 1
020 01 1
021 08 8
022 75 -
023 93 .
024 02 2
025 09 9
026 01 1
027 01 1
028 07 7
029 25 x
030 43 RCL
031 01 01
032 85 +
033 93 .
034 00 0
035 00 0
036 03 3
037 00 0
038 04 4
039 03 3
040 04 4
041 65 x
042 43 RCL
043 01 01
044 33 X²
045 75 -
046 01 1
047 93 .
048 02 2
049 08 8

```

```

050 05 5
051 01 1
052 52 EE
053 94 +/-
054 05 5
055 65 x
056 43 RCL
057 01 01
058 45 YX
059 03 3
060 85 +
061 01 1
062 93 .
063 06 6
064 06 6
065 02 2
066 01 1
067 52 EE
068 94 +/-
069 08 8
070 65 x
071 43 RCL
072 01 01
073 45 YX
074 04 4
075 75 -
076 53 (
077 02 2
078 93 .
079 07 7
080 08 8
081 07 7
082 07 7
083 75 -
084 93 .
085 00 0
086 02 2
087 05 5
088 06 6
089 03 3
090 05 5
091 65 x
092 43 RCL
093 01 01
094 85 +
095 03 3
096 93 .
097 03 3
098 00 0
099 06 6

```

```

100 03 3
101 52 EE
102 94 +/-
103 04 4
104 65 x
105 43 RCL
106 01 01
107 33 X²
108 75 -
109 01 1
110 93 .
111 04 4
112 01 1
113 06 6
114 02 2
115 52 EE
116 94 +/-
117 06 6
118 65 x
119 43 RCL
120 01 01
121 45 YX
122 03 3
123 85 +
124 01 1
125 93 .
126 08 8
127 03 3
128 04 4
129 03 3
130 52 EE
131 94 +/-
132 09 9
133 65 x
134 43 RCL
135 01 01
136 45 YX
137 04 4
138 54 )
139 65 x
140 43 RCL
141 00 00
142 85 +
143 53 (
144 93 .
145 00 0
146 06 6
147 03 3
148 03 3
149 02 2

```



150 07 7  
 151 75 -  
 152 08 8  
 153 93 .  
 154 05 5  
 155 02 2  
 156 08 8  
 157 09 9  
 158 52 EE  
 159 94 +/-  
 160 04 4  
 161 65 x  
 162 43 RCL  
 163 01 01  
 164 85 +  
 165 01 1  
 166 93 .  
 167 00 0  
 168 08 8  
 169 01 1  
 170 04 4  
 171 52 EE  
 172 94 +/-  
 173 05 5  
 174 65 x  
 175 43 RCL  
 176 01 01  
 177 33 X²  
 178 75 -  
 179 04 4  
 180 93 .  
 181 06 6  
 182 05 5  
 183 01 1  
 184 04 4  
 185 52 EE  
 186 94 +/-  
 187 08 8  
 188 65 x  
 189 43 RCL  
 190 01 01  
 191 45 YX  
 192 03 3  
 193 85 +  
 194 06 6  
 195 93 .  
 196 00 0  
 197 06 6  
 198 00 0  
 199 06 6

200 52 EE  
 201 94 +/-  
 202 01 1  
 203 01 1  
 204 65 x  
 205 43 RCL  
 206 01 01  
 207 45 YX  
 208 04 4  
 209 54 )  
 210 65 x  
 211 43 RCL  
 212 00 00  
 213 33 X²  
 214 75 -  
 215 53 (   
 216 06 6  
 217 93 .  
 218 00 0  
 219 04 4  
 220 06 6  
 221 08 8  
 222 52 EE  
 223 94 +/-  
 224 04 4  
 225 75 -  
 226 09 9  
 227 93 .  
 228 00 0  
 229 08 8  
 230 02 2  
 231 06 6  
 232 52 EE  
 233 94 +/-  
 234 06 6  
 235 65 x  
 236 43 RCL  
 237 01 01  
 238 85 +  
 239 01 1  
 240 93 .  
 241 01 1  
 242 04 4  
 243 03 3  
 244 52 EE  
 245 94 +/-  
 246 07 7  
 247 65 x  
 248 43 RCL  
 249 01 01

250 33 X²  
 251 75 -  
 252 04 4  
 253 93 .  
 254 09 9  
 255 03 3  
 256 00 0  
 257 04 4  
 258 52 EE  
 259 94 +/-  
 260 01 1  
 261 00 0  
 262 65 x  
 263 43 RCL  
 264 01 01  
 265 45 YX  
 266 03 3  
 267 85 +  
 268 06 6  
 269 93 .  
 270 04 4  
 271 05 5  
 272 06 6  
 273 07 7  
 274 52 EE  
 275 94 +/-  
 276 01 1  
 277 03 3  
 278 65 x  
 279 43 RCL  
 280 01 01  
 281 45 YX  
 282 04 4  
 283 54 )  
 284 65 x  
 285 43 RCL  
 286 00 00  
 287 45 YX  
 288 03 3  
 289 95 =  
 290 65 x  
 291 01 1  
 292 00 0  
 293 00 0  
 294 00 0  
 295 95 =  
 296 59 INT  
 297 22 INV  
 298 57 ENG  
 299 91 R/S



## APPENDIX F

### Microprocessor Program

This computer printout was reproduced on an IBM-360/67 Computer. This listing was entered by hand on an INTEL Corporation MDS-800 System, stored on a diskette, and sent to the IBM-360/67 via a high speed line.



```

; A7E
; START:
; MAIN:
CRG 0100H
PERFORMANCE CALCULATOR USING THE 8048 SYSTEM
SEL MBO
CALL CLRHX
SEL MBO
MOV R0, #36
MOV A, #00
MOV @R0, A
INC R0
MOV A, #08
MOV @R0, A
SEL MBO
SEN 1
MOV R0, #36
MOV @A, R0
RL A
MOV A, RC
SEL MBO
CPL FC
JFO HEXDG
CALL CLRHX
SEL MBO
JMP MAIN1
CALL HEXFL
MOV R7, #08
MOV R1, #35
MOV R0, #3F
SEL MBO
JMP MAIN1

MAIN1:
; GET CHARACTER
; CLEAR HEX BUFFER
; SHIFT TO HEX BUFFER
; SET COUNTER
; LOCATION OF HEX BUFFER
; LOCATION OF DISPLAY BIT PATTERN

CLRFX:
MOV R0, #32
MOV R2, #04
CLR A
MOV @R0, A
INC R0
DJNZ R2, CLRHX1
RET
; IF E GO TO BCCEIN
; IF D, GO TO FL1

HEXFL:
MOV R0, A
XRL A, #0E
JZ BCCEIN
MOV A, RC
XRL A, #0D
JZ FL1
MOV A, R0
CPL A
ADD A, #0A
CPL A
JNC MAIN
; CHECK IF ABCF, IF SO GC CN TO MAIN

```





```

HEXFL1:
ADD A,#CA
MOV R1,#32
MOV R2,#04
XCH A,@R1
SWAP A
XCHC A,@R1
XCH A,@R1
INC R1
CJNZ R2, HEXFL1
RET

FL1:
CLR F1
SET F1
MOV RC,#36
MOV @R0,#E0
RET

BCDBIN: CALL CGNV
JMP COMPUTE
82
51
23
72
E3
4E
67
DD BA

CALL CTCY
MOV A,#76
MOV A,@A
MOV A,#24
MOV @R0,A
MOV A,#77
MOV A,@A
DEC RC
MOV @R0,A
MOV A,#78
MOV A,@A
DEC R0
MOV @R0,A
CALL BIMULT
MOV A,#73
MOV A,@A
MOV R0,#27

;HEX BUFFER LOCATION
;SET COUNTER

;PUT 80 IN DP MASK

;CALL BCD TO BINARY CONVERSION ROUTINE
;CALL COMPUTATIONAL ROUTINE
;CCEFFICIENT STORAGE(BINARY FLOAT PT FORMAT)
;B0 EXPONENT
;B0 MOST SIGNIF BYTE
;B0 LEAST SIGNIF BYTE
;B1 EXPONENT
;B1 MOST SIGNIF EYTE
;B1 LEAST SIGNIF BYTE
;B2 EXPONENT
;B2 MOST SIGNIF EYTE
;B2 LEAST SIGNIF BYTE
;THIS IS BEGINNING OF THE EXEC ROUTINE WHICH
;COMPUTES POLYNOMIAL FROM STORED COEFFICIENTS
;AND A VARIABLE ENTERED AT THE KEYCARD
;MOVE ENTERED VARIABLE INTO X-POSITION

;MOVE FIRST COEFFICIENT (R2) INTO Y-LOCATION

;CALL BINARY MULT ROUTINE- MULTIPLIES NUMBERS
;IN THE X-LOCATION AND Y-LOCATION TOGETHER
;MOVE SECOND COEFFICIENT (R1) TO THE Y-LOCATION

```



```

MOV @RO, A
MOV A, #74
MOV P RO
DEC RO
MOV @RO, A
MOV A, #75
MOV P RO
DEC RO
MOV @RO, A
CALL ADD
CALL CTCY
CALL BIMULT
MOV A, #70
MOV P RO, #27
MOV @RO, A
MOV A, #71
MOV P RO
DEC RO
MOV @RO, A
MOV A, #72
MOV P RO
DEC RO
MOV @RO, A
CALL ADD

```

```

JMP BINBCC
MOV RO, #2A
MOV A, @RO
MOV @R1, A
DEC RO
DEC R1
MOV A, @RO
MOV @R1, A
DEC RO
DEC R1
MOV A, @RO
MOV @R1, A
RET

```

CTOY:

BINECD: CALL CLR

```

;ADC B2*X TO E1 BY CALLING BINARY FLOATING
;PCINT ADDITION ROUTINE
;MOVE ENTERED VARIABLE INTO Y-LOCATION (AGAIN)
;MULTIPLY (B2*X+B1)*X TC GET (B2*X*X)+(B1*X)
;MOV B0 INTO Y-LOCATION

```

```

;ACC ((B2*X*X)+(B1*X)) TO BC FOR FINAL RESULT
;OF THIS POLYNOMIAL CALCULATION--NOTE THAT
;WITH AN EXTENDED EXECUTIVE ROUTINE AND EXTRA
;COEFFICIENT STORAGE SPACE, ANY NUMBER OF
;MATHEMATICAL OPERATIONS ARE POSSIBLE
;USE BINARY TO ECD CONVERSION ROUTINE
;MOVES DESIGNATED COEFFICIENT TO Y-LOCATION

```

```

;THIS ROUTINE CONVERTS A BINARY NUMBER
;TO BINARY CDEC DECIMAL (IN PREF FOR DISPLAY)
;CLEAR REGISTERS RO-R7

```



```

MOV R1,#24
MOV A,@R1
ADD A,#69
CPL A
MOV R0,A
DEC R1
MOV A,@R1
CRL A,#80
MOV R5,A
DEC R1
MOV A,@R1
MOV R6,A
MOV R1,#00
CALL RSHIFT
CJNZ R0,FB1
CALL IBCD
JMP MOV
MOV R0,#07
MOV @R0,#C0
DEC R0
MOV A,@R0
JNZ CLRR
RET
MOV R0,#07
MOV R1,#35
FDFMASK:MOV @R1,A
DEC R0
XRL A,#03
JZ GO
DEC R1
CALL FDPMASK
JMP SPACE

```

FB1:

CLR:  
CLRR:

MOV:

FDFMASK:

GO:

```

ADD:      CALL FIXCCN
          CALL FIXEXP
          CALL SUM
          CALL RESTCRE

```

;CLEARs REGISTERS R0-R7

;MOV REGISTERS R4-R7 TO R32-R35

;GO TO DISPLAY ANSWER ROUTINE

```

;JUMP TO PAGE 2 FOR ADDITIONAL SPACE
;END PAGE 0
;THIS ROUTINE ADDS TWO BINARY FLATTENING
;POINT NUMBERS. MUST BE IN THE X-LOCATION AND
;Y-LOCATION IN THE BINARY STORAGE CONVENTION
;CHANGES NUMBERS FROM STORAGE CONVENTION TO
;WORKING CONVENTIONS SO NUMBERS MAY BE SUMMED
;EQUATES EXPONENTS THE BINARY NUMBERS TOGETHER
;THIS ROUTINE SUMS THE BINARY NUMBERS TOGETHER
;AND ENSURES ANSWER IS IN WORKING CONVENTION AND
;CHANGES ANSWER BACK TO STORAGE CONVENTION
;ENSURES NUMBER MOVED TO STORAGE LOCATION

```



RET

BIMULT: CALL FIXCCN  
CALL MULT  
CALL RESTCRE

FIXCCN: RET RO,#23  
MOV R1,#26  
XSIGN: MOV A,@RO  
RLC A,XPOS

XNEG: CLR FO  
CPL FO  
JMP XVAL  
XPCS: CLR FO  
XVAL: CLR C

YSIGN: RLC A  
MOV @RO,A  
MOV A,@R1

YNEG: RLC A  
JNC YPOS  
CLR F1  
CPL F1

YPCS: JMP YVAL  
YVAL: CLR F1  
CLR FC  
CPL C

SHIFTX: RLC A  
MOV @R1,A  
RET  
MOV A,@RO  
RRC A  
MOV A,@RO,A  
DEC RO  
LJNZ R1,SHIFTX

FIXEXP: RET C  
CLR C  
MOV RO,#24

;THIS ROUT MULTIPLIES 2 BINARY FLOATING POINT  
;NUMBERS. TO CALL AND USE THIS ROUTINE,  
;NUMBERS TO BE MULTIPLIED TOGETHER MUST BE IN  
;X-LOCATION AND Y-LOCATION IN BINARY STORAGE  
;CONVENTION  
;CHANGES NUMBERS FROM STORAGE CONVENTION TO  
;WORKING CONVENTION  
;MULTIPLIES BINARY NUMBERS TOGETHER AND  
;ADDS EXPONENTS, AND ENSURES NUMBER IS RETURNED  
;TO WORKING CONVENTION  
;RESTORES ANSWER BACK TO STORAGE CONVENTION  
;AND ENSURES IT IS MOVED TO THE PROPER STORAGE  
;LOCATION

;MCVF MSB INTO ACCUMULATOR  
;ROTATE MSBIT INTO CARRY

;IF CARRY SET, X IS -; THEREFORE SET FO FLAG

;X IS POSITIVE; THEREFORE CLEAR FC FLAG,  
;SET CARRY, ROTATE 1 INTO UNDERSTOCK MSBIT OF X

;RESTORE INTO X, NOW IN WORKING CONVENTION  
;DO THE SAME FOR Y, EXCEPT USE THE F1 FLAG

;THIS SUBROUTINE SHIFTS RIGHT WITH CARRY THE  
;NUMBER SPECIFIED BY RO A NUMBER OF TIMES  
;SPECIFIED BY R1

;THIS SUBROUTINE ADJUSTS THE EXPONENT OF THE  
;SMALLER OF 2 NUMBERS (X OR Y) SO THE EXPONENTS





; EQUAL AND THE NUMBER IS SHIFTED THE PROPER  
;NUMBER OF TIMES

```

MOV R1, #27
CPL A, @R0
ADD A, @R1
JC XLTY
CPL A
JZ XEQY
MOV R7, A
ADD A, @R1
MOV R1, A
MOV R1, #26
MOV A, @R1
RRC A
MOV @R1, A
DEC R1
MOV A, @R1
RRC A
MOV @R1, A
CLR C
DJNZ R7, YAGIN
JMP XEQY
CLR C
MOV A, @R1
CPL A, @R0
ADD A, R7, A
ADD A, @R0
MOV @R0, A
MOV R1, #04
MOV R0, #23
CALL SHIFTX
CLR C
DJNZ R7, XAGIN
MOV R0, #24
MOV A, @R0
MOV R6, A
RET

```

XGTY:

YAGIN:  
SHIFTY:

XLTY:

RCTX:

XAGIN:

XEQY:

SUM:

ALLPCS:

```

JFO CHECKY
JF1 X+Y-
CALL BINACD
CLR FO
JNC REG1
CALL SHIFTR
CALL EXPACC
JMP FINISH

```

;THIS ROUTINE ACCS TWO BINARY NUMBERS THAT ARE  
;IN WORKING CONVENTION  
;CHECK SIGNS CF ADDENDS  
;IF BOTH ARE +, ADD THE NUMBERS TOGETHER AND  
;CLEAR FO( +ANSWER). IF ANY CARRY, SHIFT,  
;RAISE EXP AS NECESSARY TO REMAIN IN WORKING  
;CONVENTION



```

REG1:  MOV R5,A
        JMP FINISH
CHECKY: JF1 ALLNEG
X-Y+:  CALL CPLY
        CALL SUB
        JMP FINISH
X+Y-:  CALL CPLX
        CALL SUB
        JMP FINISH
ALLNEG: CLR FO
        CPL FO
        CALL BINADD
        JNC REG1

        CALL SHIFTR
        CALL EXPACC
FINISH: RET
SUB:    JF1 REGSUE
        CALL FIXY
        CALL BINADD
REGSUB: JNC REG2
        CLR FO
        CPL FO
        MOV R5,A
        CALL NEGACC
        JMP FINI
REG2:  MOV R5,A
        CLR FO
        CALL CPLR
        RET
FINI:  CLR R0,#2C
        MOV R1,#25
        MOV A,@R0
        MOV R2,A
        INC RC
        MOV A,@R0
        MOV R3,A
        INC RC
        MOV A,@R0
        ADD A,@R1
        MOV R4,A
        INC R0
        INC R1
        MOV A,@R0
        ACCC A,@R0
        RET
EXPACC: MOV A,R6
;IF ONLY X IS NEGATIVE, CCPLEMENT Y AND CALL
;SUBTRACTION ROUTINE.
;IF ONLY Y IS NEGATIVE, CCPLEMENT X AND CALL
;SUBTRACTION ROUTINE
;IF BOTH NUMBERS -, SET FO FLAG(-ANSWER)
;AND ADD NUMBERS
;IF CARRY, SHIFT, AND RAISE EXP AS NECESSARY
;TO REMAIN IN WORKING CONVENTION
;SEE 'FIXY:' FOR EXPLANATION
;ADD PREPARED NUMBERS> IF NO CARRY, ANSWER+
;IF CARRY, ANSWER- AND MUST ADD BORROW TO SUM
;AND SET FO FLAG
;IF ANSWER+, CCPLEMENT ANSWER AND CLEAR FC
;ADD BINARY NUMBERS THAT ARE IN X AND Y
;LOCATIONS IN RESIDENT DATA MEMORY
;LEAVE ANSWER IN ACCUMULATOR, R4, F3, R2
;BYTE POSITIONS:____MSB
;INCREASE EXPONENT(REGISTER 6) BY 1

```



```

SHIFT:  ADD A,#C1
        MOV R6,A
        RET
        MOV A,R5,A
        MOV A,R4
        RRC A,R4
        MOV R4,A
        MOV A,R3
        RRC A,R3
        MOV R3,A
        MOV A,R2
        RRC A,R2
        MOV R2,A
        RET
NEGACC: MOV A,R2
        ADDC A,#00
        MOV R2,A
        MOV A,R3
        ADDC A,#0C
        MOV R3,A
        MOV A,R4
        ADDC A,#00
        MOV R4,A
        MOV A,R5
        ADDC A,#0C
        MOV R5,A
        RET
CPLX:   MOV R0,#20
        MOV R7,#04
        MOV A,@R0
        CPL A,@R0,A
        INC R0
        CJNZ R7,NEXT1
        RET
        MOV R1,#25
        MOV R7,#02
        MOV A,@R1
        CPL A
        MOV @R1,A
        INC R1
        CJNZ R7,NEXT2
        RET
        MOV A,R6
        CPL A
        CPL A,#C1
        CPL A
;WITH MSB IN ACCUMULATOR, RCTATE ANSWER RIGHT
;ANSWER PCSITICNED NOW AS FCLLCWS
;R6 R5 R4 R3 R2
;EXP MSB LSB
;ADD BORRCW TC ANSWER
;COMPLEMENT X
;COMPLEMENT Y
;SUBTRACT 1 FROM EXPONENT(REGISTER 6)

```



```

MOV R6,A
RET

CLRX:
MOV R1,#20
MOV R2,#05
CALL CLEAR
CLR F0
RET

CLRY:
MOV R1,#25
MOV R2,#03
CALL CLEAR
CLR F1
RET

FIXY:
CLR R0,#20
MOV A,@R0
ADD A,#FF
MOV @R0,A
INC R0
MOV A,@R0
ADDC A,#FF
MOV @R0,A
INC R0
MOV A,@R0
ADDC A,#0C
MOV @R0,A
INC R0
MOV A,@R0
ADDC A,#00
MOV @R0,A
RET

MULT:
CALL ROUNCX
MOV R7,#1C
MOV R0,#24
MOV R1,#27
ADD A,@R0
ADD A,#80
JNC NGBQR
ADDC A,#00
ADD A,@R1
MOV R0,#24
MOV R6,A
CALL EXPALD
DEC R1
MOV A,@R1

EXP:
SETREG:

;ROUND NUMBER IN X-LOCATION TO 2-BYTE NUMBER
;ADD EXPONENTS OF MULTIPLICATION FACTORS
;(BIAS OF EXPONENT IS 7F)

;MOVE EXPONENT SUM INTO EXPONENT REGISTER(R6)
;ADD 1 TO EXPONENT BECAUSE OF EXPECTED CARRY

;BEGIN MULTIPLICATION

```

```

;INITIALIZE X-LOCATION FOR CLEAR ROUTINE

;INITIALIZE Y-LOCATION FOR CLEAR ROUTINE

;THIS ROUTINE IS USED IN (Y-X) OPERATIONS
;AND MAKES ALLOWANCE FOR ONLY 2-BYTE SIZE OF Y
;BY ADDING FF(COMPLEMENT OF 00) TO THE 2 LEAST
;SIGNIFICANT BYTES OF X

```

```

;*****
;END OF PAGE 1
;*****
;INITIALIZE X-LOCATION FOR CLEAR ROUTINE

```





```

MOV R3,A
DEC R1
MOV A,@R1
MOV R2,A
MOV A,@R0
MOV R1,A
DEC R0
MOV A,@R0
MOV R0,A
CLR C
CLR A
MOV R5,A
MOV R4,A
MOV A,R5
CALL SHIFTR
JNC BMP2
CLR C
MOV A,R4
ADD A,R0
MOV R4,A
MOV A,R5
ADDC A,R1
MOV R5,A
CJNZ R7,BMP1
MOV A,R5
CALL SHIFTR
JF0 NCWY
JF1 PCSNEG
SAMSIN: CLR FC
NOWY: JMP OUT
PCSNEG: CLR F0
CLT: CPL F0
ROUNDX: MOV R0,#21
MOV A,@R0
CLR C
RLC A
JNC END
INCR
ADDC A,@R0
MOV @R0,A
INCR
CLR A
ADDC A,@R0
MOV @R0,A
JNC END

```

BMP1:

BMP2:

SAMSIN:

NOWY:

PCSNEG:

CLT:

ROUNDX:

```

;MULTIPLIER IS IN R3 R2
;MULTIPLICAND IS IN R1 R0
;ANSWER IS IN R6 R5 R4 R3 R2
;EXP MSB LSB

```

```

;CHECK FOR SIGNS

```

```

;PUT ROUNDOFF BYTE INTO ACCUMULATOR AND CHECK

```

```

;IF X AND Y HAVE SAME SIGN, PRODUCT SIGN IS +
;IF NOT, PRODUCT IS -

```

```

;PUT ROUNDOFF BYTE INTO ACCUMULATOR AND CHECK
;FOR MSEIT BY RCTATING LEFT

```

```

;IF CARRY SET,MUST ADD 1 TO NEXT SIGNIF BYTE

```

```

;ALLOW FOR CARRYOVER INTO MSB AND INTO CARRY

```



```

MOV R1,#01
CALL SHIFTX
MOV R0,#24
MOV A,@R0
ADD A,#01
MOV @RC,A
MOV R0,#21
CLR A
MOV @R0,A
DEC RC
MOV @R0,A
RET
SHIFTL: MOV A,R2
        RLC A
        MOV R2,A
        MOV A,R3
        RLC A
        MOV R3,A
        MOV A,R4
        RLC A
        MOV R4,A
        MOV A,R5
        RLC A
        MOV R5,A
        RET
RESTORE: CLR C
LCCF:   CALL EXPNEG
        CALL SHIFTL
        JNC LOOP
        JFO ZERC
        CLR C
        CALL SHIFTR
        CALL EXPACD
        JMP STORE
        CALL SHIFTR
        CALL EXPACD
        MOV R0,#24
        MOV @R6,A
        MOV @R0,A
        DEC R0
        MOV A,R5
        MOV @R0,A
        DEC R0
        MOV A,R4
        MOV @R0,A
        DEC R0
        MOV A,R3
        MOV @R0,A

```

END:

SHIFTL:

RESTORE:  
LCCF:

ZERC:

STORE:

;SHIFT AND INCREASE EXPCNENT IF NECESSARY

;THIS RCUT SHIFTS REGS R2-R5 LEFT WITH CARRY

;DECREMENT EXP, SHIFT LEFT UNTIL CARRY FILLED

;FCR +NUMBER,CLR CARRY AND SHIFT ZERO RIGHT INTO  
;UNDERSTCOD,MSBIT OF MSE AND ACC EXPCNENT

;FCR -NUMBER, SHIFT 1 RIGHT INTO MSBIT CF MSB

;STORE ANSWER IN ORIGINAL PCSTICION CF X  
;NCW IN STORAGE CONVENTION



```

CPLR:
DEC R0
MOV A,R2
MOV @R0,A
RET A,R2
CPL A,R2
MOV R2,A
MOV A,R3
CPL A,R3
MOV R3,A
MOV A,R4
CPL A,R4
MOV R4,A
MOV A,R5
CPL A,R5
MOV R5,A
RET A
CLR @R1,A
INC R1
CJNZ R2,CLEAR
RET
MOV R0,#18
CONT:
CALL RSHIFT
CJNZ R0,CCNV1
MOV R0,#23
MOV R1,#04
MOV A,#04
CALL FTCH1
JMP BFP
MOV R0,#36
MOV @RC,#E0
JMP FEXDGI
NOBCR:
CPL A,R0
XCH A,@R1
MOV A,@R1
DEC A
CJNZ R0,DECA
JMP EXP
LSHFT:
CLR A,#C7
MOV R0,A
XCH @R0,A
LSHFT1:
RLC
;CCMPLEMENT R2,R3,R4,R5

;CLEAR SPECIFIED REGISTERS

;THIS ROUTINE IS CONTINLATION FROM PGE 3 WHICH
;WAS NECESSARY DUE TO LACK OF SPACE

;THIS ROUTINE NOW RETURNS TO PAGE 3(BFP)
;CONTINUED FROM PAGE 0
;BACK TO PAGE 0

*****
;END OF PAGE 2
*****
;LCAD COUNTER

```



RSHF1:	XCH @RO,A
	DJNZ RO,LSHF1
	XCH RO,A
	RET C
RSHF1:	MOV A,#01
	XCH RO,A
	XCH @RO,A
	RRC @RO,A
	INC RC
	INC RO,A
	XCH RSHF2
	JB3 RSHF1
	JMP RET
RSHF2:	XCH @RO,A
FTCH1:	MOV @R1,A
	XCH @RO,A
	DEC RO
	DEC R1
	DEC A
	JNZ FTCH1
	INC R1
	RET
FTCH2:	XCH @RO,A
	MOV @R1,A
	XCH @RO,A
	INC RC
	INC R1
	DEC A
	JNZ FTCH2
	INC R1
	RET
LPGT4:	MOV A,#C5
UGT41:	CALL GT4
	INC A
	INC LGT42
	JB3 UGT41
	JMP A,#04
LCGT4:	MOV A,GT4
LGT41:	CALL A
	DEC LGT41
	JNZ LGT41
	RET
LGT42:	XCH RO,A
GT4:	XCH @RO,A
	ADD A,#33
	JB7 GT41
	CPL A





GT41:	ADD A, #30 CPL A JB3 GT42 CPL A ADD A, #03 CPL A XCF @RO, A XCH RO, A RET MOV A, #05 UGT71: CALL GT7 INC A JB3 LGT72 JMP UGT71 LGT7: MOV A, #04 LGT71: CALL GT7 DEC A JNZ LGT71 LGT72: RET GT7: XCH RO, A XCH @RO, A CPL A JB7 GT71 ADD A, #30 GT71: JB3 GT72 GT72: ADD A, #03 CPL A XCH @RO, A XCH RO, A XCH @RO, A XCH RO, A RET IBIN: MOV RO, #18 IBIN1: CALL RSHFT CJNZ RO, IBIN2 RET IBIN2: CALL LGT7 CPL IBIN1 FBIN: MOV RO, #19 FBIN1: CALL UPGT4 CJNZ RO, FEIN2 RET FEIN2: CALL LSHFT CPL FBIN1 IBCD: MOV RO, #18 IBCD1: CALL LSHFT CJNZ RO, IBCD2 RET IBCD2: CALL LOGT4	
		;THIS ROUTINE CONVERTS INTEGER BCD TO ;INTEGER BINARY
		;CONVERTS FRACTICNAL BCD TO FRACTICNAL BINARY
		;INTEGER BINARY TO INTEGER BCD



```

FBCC:
FBCC1:
    JMP IBCD1
    MOV RO,#19
    CALL UPGT1
    DJNZ RO,FBCD2
    RET
    CALL RSHFT
    CALL FBCD1
    MOV RO,#40
    CALL LSHIFT
    JC BFP2
    CJNZ RO,BFP1
    JMP ZERC
    CALL RSHIFT
    MOV A,#2A
    XCH A,RO
    ADD A,#5E
    MOV @RO,A
    DEC RO
    MOV A,R1
    MOV @RO,A
    DEC RO
    MOV A,R2
    MOV @RO,A
    RET
    RC,#2C
    CLR A
    MOV @RO,A
    MOV BFP3
    JMP RO,#32
    MOV A,#04
    MOV R1,A
    CALL FTCH2
    MOV A,@RC
    MOV RO,A
    JBO RET
    CALL RSHFT
    CALL RSHFT
    CALL RSHFT
    CALL RSHFT
    MOV A,RO
    RR A
    JMP LDHX1
    CALL LCFX
    CALL IBIN
    MOV RO,#27
    MOV R1,#23
    CALL FTCH1
    CALL LCFX

;FRACTIONAL BINARY TO FRACTIONAL BCD
;
;CONTINUING FROM PAGE 2(CCNT)
;
;RETURN IF BIT 0 IS SET
;
;THIS ROUTINE TAKES BCD NUMBER IN HEX BUFFER,
;CONVERTS IT TO BINARY PLACES IT IN STCRAGE
;CONVENTION, AND RELOCATES IT IN REGISTERS
;2A 29 28
;EXP MSB LSB

```



END OF PROGRAM



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7. LCDR W.M. Siegel, Code 35 1  
COMLATWINGPAC  
NAS Lemoore CA 93245
8. LT G.L. Koger 1  
435 Burlwood Drive  
Lemoore CA 93245
9. CDR L. Chrans, Code 3105A 1  
A-7 Program Office  
Naval Weapons Center  
NAF China Lake CA 93555







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